DATA PROCESSING

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Recording data at the point of sale

Three data recording units that can be fitted retrospectively to standard cash registers

The ideal way to obtain basic data is to capture it at source as a byproduct of some other operation. When, for instance, a sale is made, it is best to record all the pertinent facts about it immediately in a form in which it can be introduced directly into a data processing system. Avoiding having to transcribe the data from one document to another means that information is ready sooner and it eliminates a manual operation with its associated expense and liability to error. Three different types of data recording unit that can be fitted to Sweda cash registers are described in this article

ONE of the unwritten laws of data processing is that, whenever possible, information should be captured at source. And if capturing the information at source can be done automatically while some other necessary operations are being performed, so much the better. In shops, the occasion, obviously, is when a purchase is made and the value is rung up on the cash register. To record such transactions, the Svenska Dataregister* company of Sweden, makers of Sweda cash registers, have over the past year or so designed and developed no fewer than three data recording units that can be fitted to any of their existing standard machines. Two of these units record data by mechanically punching holes in paper. One perforates standard 5-channel paper tape and the other punches additional data into Kimball tags. The third data recording unit prints distinctive symbols on the normal paper audit roll produced by cash registers. These symbols can be read automatically by an electronic machine known as the Sweda E-3 audit strip reader.

The E-3 reader is still being developed and a prototype is, at this moment, undergoing practical trials in collaboration with the Nordiska Kompaniet department store in Stockholm. The first commercial installation in the world to include an E-3 reader will be completed in 1961 at the head office of the Leeds Industrial Co-operative Society. Brief details of the manner in which the machine will be used are given later in this article.

Automatic reading is still a relatively new technique, but the other two data recording units have been fully developed and are already in everyday use. Several retail organizations in the United States are equipped with cash registers that punch data directly into Kimball tags, and one of these machines is at present undergoing trials in Great Britain.

The unit for punching 5-channel tape is available in Great Britain and, as already mentioned, can be fitted retrospectively to standard Sweda cash registers. It costs £200. This unit is of special interest to organizations contemplating acquiring or hiring time on a computer because most computers are equipped with high-speed photo-electric punched tape readers; consequently, sales data can be read from the tape produced by the cash register.

The 5-channel mechanical tape punch is contained within a small unit which fits on the side of a Sweda cash register. Any desired hole code can be punched in the tape to suit the data processing system, but the one most frequently used records numerical data in conventional decimal binary form† in the first four channels of the tape—the fifth channel is reserved for a parity digit. Parity digits are used when data are being transcribed from the paper tape to confirm that the information has been read correctly. The rule governing the parity check, as it is called, is that there must always be an odd number of holes in each row of the tape, and a hole is punched in the fifth channel, if necessary, to achieve this condition.

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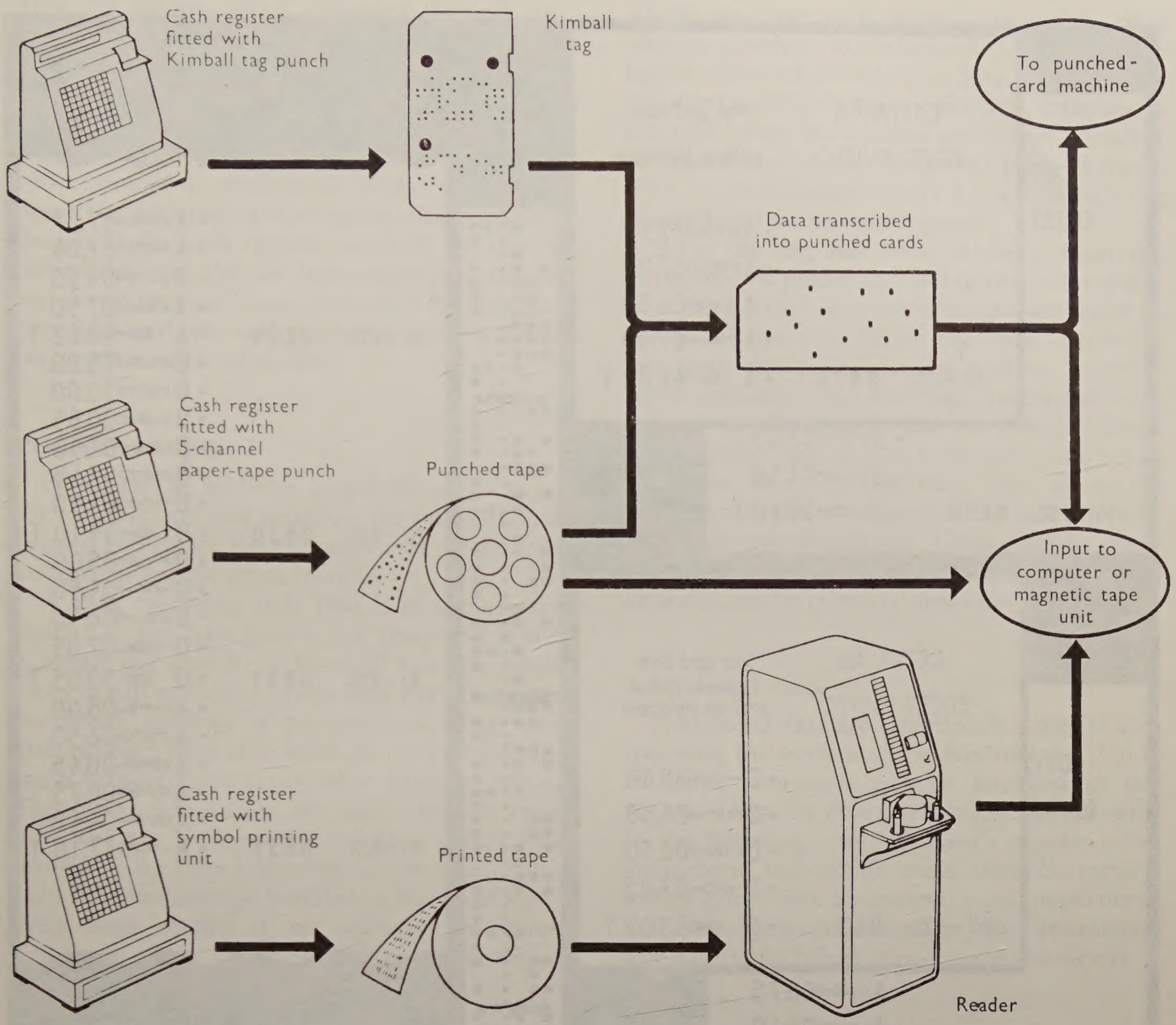
*London Office Machines Limited, Terminal House, Grosvenor Gardens, London, S.W.1, represent Svenska Dataregister in Great Britain.

†See the "Universal language of computing," *Data Processing*, January-March, 1959.

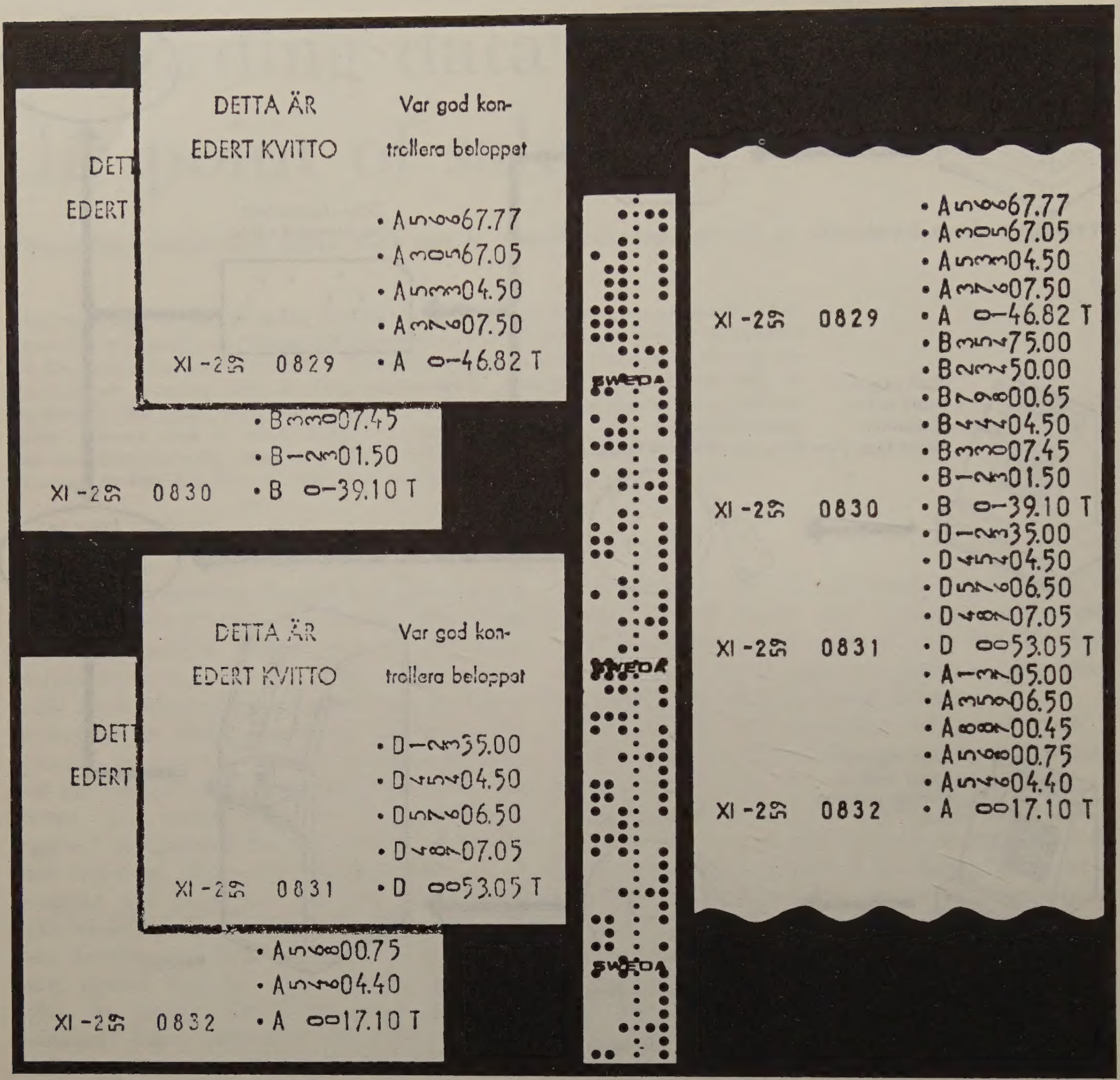

Cash register fitted with Kimball tag punch
Kimball tag
To punched-card machine
Data transcribed into punched cards
Cash register fitted with 5-channel paper-tape punch
Punched tape
Input to computer or magnetic tape unit
Cash register fitted with symbol printing unit
Printed tape
Reader

Three different methods of handling the information from cash registers

The mechanical paper-tape punch fits on the side of a standard Sweda cash register

Each row of holes punched in the tape represents one character. An unusual feature of the Sweda mechanical punch is the fact that 12 rows are punched simultaneously. Every time the cash register is operated, up to ten characters entered on the keyboard plus two items of fixed information (usually control signals of some sort) are recorded in the tape. This block of 12 characters is referred to as a "word," to conform with the generally accepted nomenclature of computing.

More than one word can be punched in the tape for each transaction, although this means that the operator has to make two separate entries on the keyboard. In the majority of cases, where the transaction is of a simple nature, it is probable that all the data required can be contained in one word. For example, the price of the



DETTA ÄR
EDERT KVITTO

Var god kontrollera beloppet

• A 67.77
• A 67.05
• A 04.50
• A 07.50
XI -2 0829 • A —46.82 T

• B 07.45
• B— 01.50
XI -2 0830 • B —39.10 T

DETTA ÄR
EDERT KVITTO

Var god kontrollera beloppet

• D— 35.00
• D 04.50
• D 06.50
• D 07.05
XI -2 0831 • D 53.05 T

• A 00.75
• A 04.40
XI -2 0832 • A 17.10 T

SWEDA
SWEDA
SWEDA

• A 67.77
• A 67.05
• A 04.50
• A 07.50
XI -2 0829 • A —46.82 T
• B 75.00
• B 50.00
• B 00.65
• B 04.50
• B 07.45
• B— 01.50
XI -2 0830 • B —39.10 T
• D— 35.00
• D 04.50
• D 06.50
• D 07.05
XI -2 0831 • D 53.05 T
• A— 05.00
• A 06.50
• A 00.45
• A 00.75
• A 04.40
XI -2 0832 • A 17.10 T

Customers' receipts, punched paper tape and a printed audit roll are all produced simultaneously by the cash register

commodity bought would account for, at the most, six of the 12 characters available, three characters would be used to indicate the department, sales group and assistant responsible for the sale, one of the remaining characters would show whether the value recorded was a total or not and the last two characters would denote the end of the word or other control information.

Alternatively, five characters could be used to record the price, leaving four characters for the department and the item sold. Where more detailed information is required to identify the item, one entire word is allocated for this purpose and the value and the staff code number of the assistant are recorded in a second word.

A number of adding registers, up to a total of nine, can be fitted to Sweda cash registers to suit the nature of the work performed, and totals compiled in these registers can also be recorded in the paper tape whenever this is required. For example, one of the registers can be set to total the value of all sales made that day. At closing time this total can be punched in the paper tape.

The storage and take-up spools for the tape are mounted on a common spigot within the data recording unit. Setting up the punch is a simple operation. A length of tape is unwound from the storage spool, threaded through the mechanical punch situated immediately above and fixed to the take-up spool. A feed mechanism operated by a lever simplifies the process of threading the tape through the punch. Each time this lever is operated a four or five digit code number is perforated in the tape. This figure is a composite code number that identifies the particular cash register to which the tape is being fitted and also the department and store in which it is located. Thus, even after the tape has been removed, the cash register on which it was produced can be identified.

Printed receipts

Of course, in addition to punching the tape, the cash register still produces the conventional printed receipt for the customer and the printed audit strip for the office records.

A data recording unit that is in some ways similar to the tape punch just described is the Kimball tag punch. A Kimball tag is a small piece of stiff card into which data that identify a particular product is pre-punched. Tags are fitted to each item and, when an item is sold, the tag is removed and returned to the sales office. The pre-punched data are automatically read from the tag by a special machine which will transcribe the data into a conventional punched card that can then be handled in the usual way. Why then should it be necessary to enter additional data on these pre-punched tags? There are three main reasons: to modify data already punched, to confirm existing data on the tag or to record entirely new data. Kimball tags are often used in clothing stores and, if the goods are sold below the marked price, it is necessary to record on the tag the actual price charged. This is done automatically by a Kimball tag punch fitted to the cash register.

After the tag has been removed from the garment, it is placed in a slot in the cash register and the amount is entered on the keyboard in the usual manner. When the cash register is operated, the price charged will be punched simultaneously into the tag. Additional data such as the department and the sales assistant's code number can also be recorded in the tag at the same time. In this way, data about the product and the conditions of the sale are combined on one document. Consequently, more comprehensive and informative statistical analyses can be prepared from the data.

Additional data

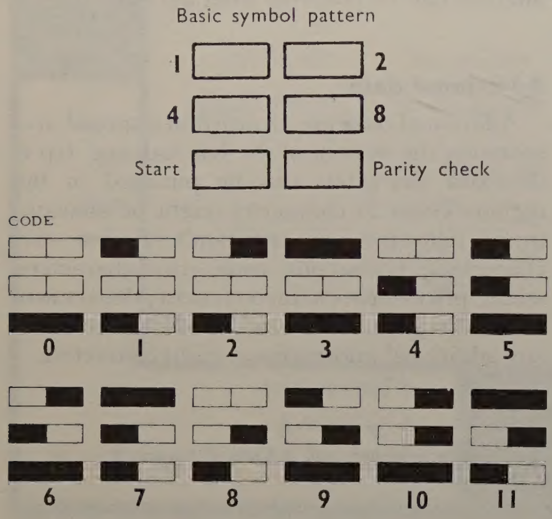
Additional data are recorded in a special area spanning the bottom of the Kimball tag. Up to 24 extra characters can be punched in this region. These 24 characters might be allocated in the following way: assistant's number—five characters; transaction code—two characters; selling price—five characters; store, department and cash register code number—four characters; any additional information—eight characters.

Data are punched in 5-channel paper tape

Cash register equipped with a Kimball tag punch

Perhaps the most interesting innovation by the Svenska Dataregister company is a machine that can read and interpret, automatically, 16 special symbols printed on a continuous roll of paper. There is one symbol for each decimal digit plus six additional symbols for sterling values and special instructions. Each symbol is constructed from a number of small individually printed rectangles where each rectangle has a precise meaning. The code, and the formation of the symbols, is shown in the illustration.

The area occupied by one symbol is divided into six regions arranged in two vertical columns of three. A rectangle can be printed in any one of these six regions. If a rectangle is printed in the region at the top of the left-hand column it represents the figure 1 (‾: :), if printed at the top of the right-hand column it represents 2 (: :‾). A rectangle printed directly below the 1 represents 4 (—: :) and in the region to the right 8 (: :—). A rectangle is always printed in the lowest region of the left-hand column to indicate the start of a symbol (:_ :) and the region on the right of this is for the parity check digit (: :_). Each symbol must contain an even number of rectangles, and one is printed in the parity position to conform with this rule.



How figure symbols are constructed. The black rectangle which is always printed at the bottom left-hand corner denotes the start of a symbol. The bottom right-hand rectangle is only black in those cases where otherwise there would be an uneven number of black rectangles

With such a code, obviously any of the ten decimal digits can be represented by printing rectangles in the appropriate positions. For example, 3 is indicated by printing the 1 and 2 rectangles (‾: ‾:). Similarly, for 5, rectangles 1 and 4 are printed (⁼:). The sterling value 11 pence is represented by rectangles 8, 2 and 1 (‾: ⁼). In order to complete the symbols a rectangle is always printed in the start position (:_ :). Also a parity rectangle is printed whenever necessary. The final form of each of the ten decimal symbols and those for the sterling values 10 pence and 11 pence is shown in the illustration.

Printing symbols

Symbols recording the price charged and other numerical data entered on the keyboard of the Sweda cash register are printed on a roll of plain paper. The cash registers contain a small unit that can print up to ten characters at a time on both a customer's receipt and an audit roll. The only modification to this unit is to replace the normal type fount used for the audit roll with the special type needed to print the symbols. This is an inexpensive alteration.

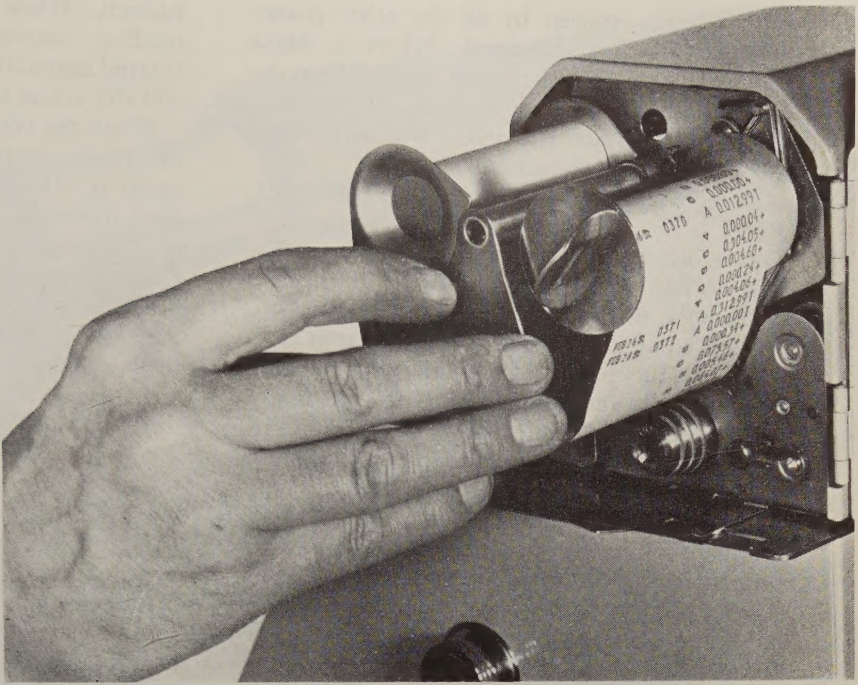
Audit rolls on which these symbols have been printed can be read rapidly and accurately by the Sweda E-3 reader. This machine reads 100 rows a second and, as each row can contain up to 10 symbols, the maximum reading speed is 1,000 characters a second.

Operation of reader

When the reader is to be operated, the audit roll is placed on a spigot and the leading edge is pushed down through an open slot and then attached to the wind-up spigot. All these items are readily accessible to an operator seated in front of the machine as they are all situated on a small projecting table. When the start button is pressed, the audit roll is drawn past an illuminated rectangular slot at high speed. A lens projects the image of the one printed line framed by the slot on to an assembly of 60 photo-electric cells arranged in ten groups of six.

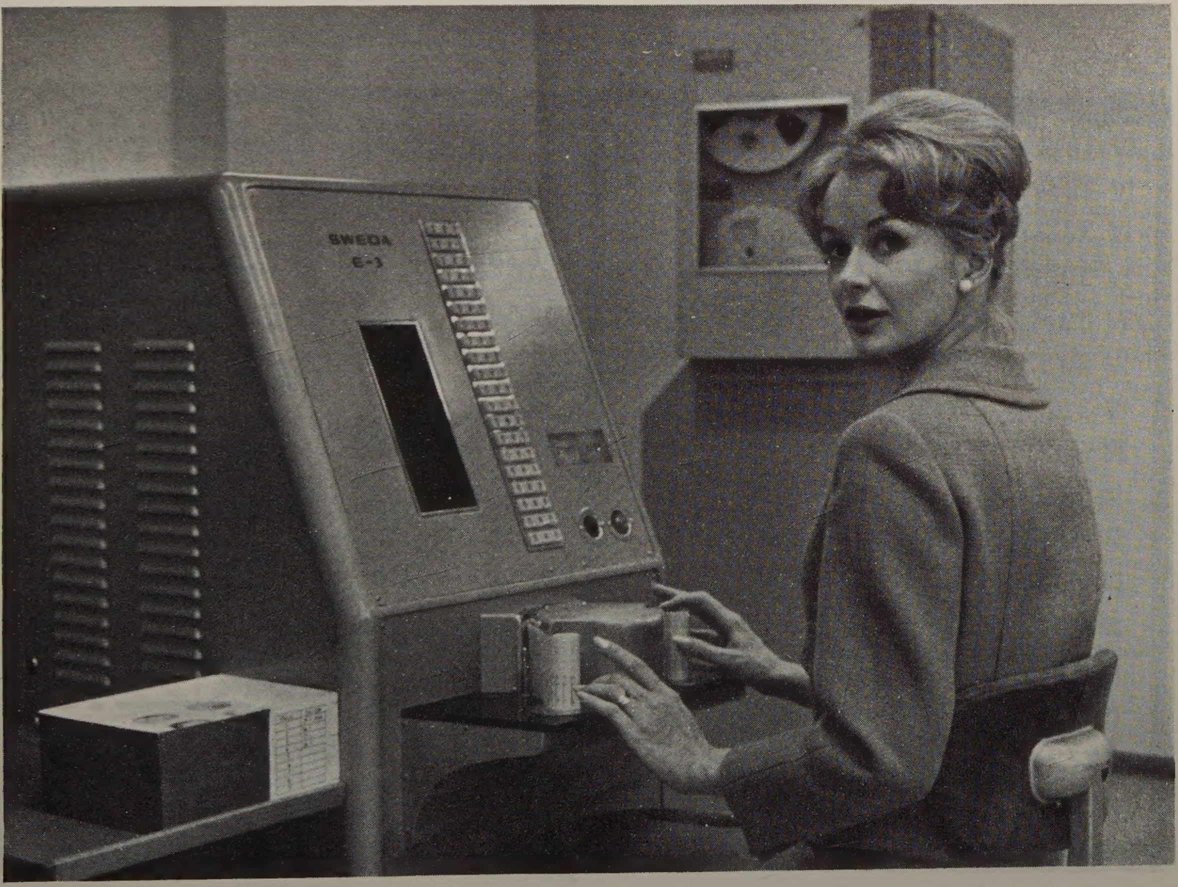
Each group of six photo-electric cells is arranged in two columns of three, corresponding to the basic pattern from which the printed symbols are constructed.

As the projected image comes into the correct reading position, the intensity of the light falling on all the cells intended to detect the start of the symbols diminishes because, of course, black rectangles are always printed in these positions. This diminution in signal strength triggers the reading action. Immediately, the strengths of the



(Right) Audit-roll printing unit of cash register

(Below) Printed roll in position in the Sweda E-3 reader



signals being emitted by all the other photoelectric cells are measured. Where a black rectangle is printed, the signal emitted from the corresponding cell will be low. Conversely, where no rectangle is printed, the signal from the cell will be a maximum.

Thus the pattern made by the printed rectangles is detected and the symbol recognized. This information is then sent to an information store. A parity check is performed and, if this is satisfactory, the information is passed directly to either a computer or a magnetic tape unit.

Should the parity check fail, the machine stops instantly and the line containing the faulty symbol is projected on to a viewing screen. A red light appears next to the character that cannot be identified. The actual pattern detected by the reading machine is indicated on six illuminated push buttons arranged in a group to correspond with the basic pattern of the symbol.

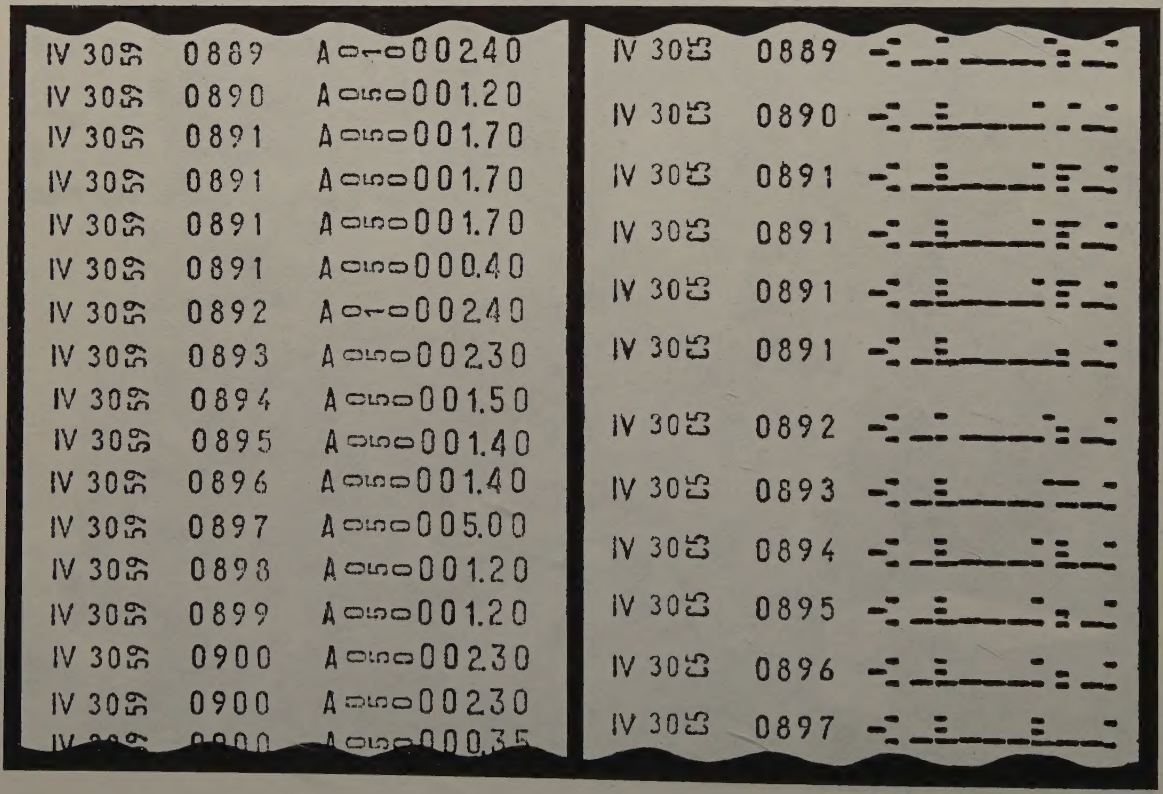
After examining the image on the viewing screen the operator, if he or she can decide what the defective symbol should be, enters this information in the machine by pressing the appropriate buttons needed to complete the pattern. When the start button is pressed, reading continues. Should the information entered manually also be incorrect, the machine will still refuse to function.

When the complete audit roll has been read, the reader stops and the winding mechanism opens to allow the roll to be removed. At any time during a reading sequence, the machine can be halted by pressing a stop button. The reader stops immediately after the next line has been read, consequently no information is lost.

Although the symbols printed do not resemble their corresponding arabic numerals, the code can be learnt and recognized by human operators. The real advantage, however, is that, with a code pattern designed to suit the capabilities of a machine, maximum accuracy of reading can be obtained. Also this method of recording data only involves minor modifications to existing Sweda cash registers—simply the replacement of the existing printing unit with a new one.

It was stated earlier that the first organization to install one of these readers will be the Leeds Industrial Co-operative Society. The data processing problem the Leeds Society has is

Section of an audit roll and the corresponding section printed with symbols



```
IV 30   0889   A   002.40
IV 30   0890   A   001.20
IV 30   0891   A   001.70
IV 30   0891   A   001.70
IV 30   0891   A   001.70
IV 30   0891   A   000.40
IV 30   0892   A   002.40
IV 30   0893   A   002.30
IV 30   0894   A   001.50
IV 30   0895   A   001.40
IV 30   0896   A   001.40
IV 30   0897   A   005.00
IV 30   0898   A   001.20
IV 30   0899   A   001.20
IV 30   0900   A   002.30
IV 30   0900   A   002.30
```

```
IV 30   0889
IV 30   0890
IV 30   0891
IV 30   0891
IV 30   0891
IV 30   0891
IV 30   0892
IV 30   0893
IV 30   0894
IV 30   0895
IV 30   0896
IV 30   0897
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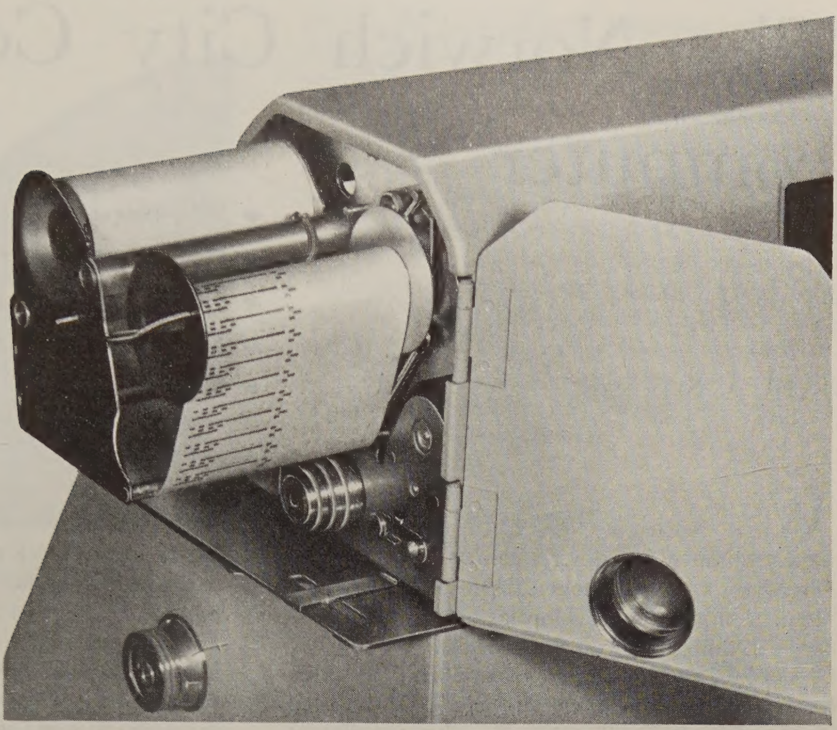


It is a comparatively inexpensive modification to change the standard audit-roll print wheels and replace them with symbol print wheels

common to all co-operative societies and is that of assessing the dividend payable to each member. To be able to work this out, it is necessary to keep a record of the total value of purchases made by each member throughout the year. As the Leeds Society has a membership of 180,000 who make, on average, 600,000 purchases each week, this is no small task.

Data processing system

The way the Leeds Society propose to handle this problem is to record the member's number and the value of the purchase on the Sweda cash register audit roll in the special printed code already described. These rolls will then be passed through an E-3 reader and the data obtained from them will be recorded directly on magnetic tape. Sweda have built a special magnetic tape recording machine for this purpose known as the E-48. It is fitted with four magnetic tape units to enable it to perform another important function, that of sorting the data into order. In this instance, it means sorting 600,000 items each week under 180,000 headings. Thus throughout the year a record of the total value of purchases made by each member up to the current week will be known. With this information it is a simple matter, once the dividend is declared, to calculate the amounts due to each member.

By using this method of reading and sorting data, the Leeds Society ultimately expect to reduce their accounts staff by about 75 per cent (from 90 to approximately 20 persons). Dividend payments will be calculated more quickly, office accommodation will be released for other purposes and the volume of paper records that have to be kept will be drastically reduced.

Many criticisms have been made of point-of-sale recording, especially the fact that the accuracy of the data entered cannot be guaranteed. Some precautions can be taken, such as pre-recording data on documents like Kimball tags which are then attached to the goods. Nevertheless, techniques must and will be developed to overcome these problems because to record data at the point of origin, as a by-product of another operation, is by far the best way of acquiring the necessary information. The alternative, manual transcription, is a redundant clerical operation that provides a further source of potential errors and, in itself, does nothing to guarantee the accuracy of the original data.

The Norwich City Council computer

- **Why Norwich (England) chose a computer**
- **How they operate it**
- **Jobs performed**
- **Experience gained**
- **Savings made**

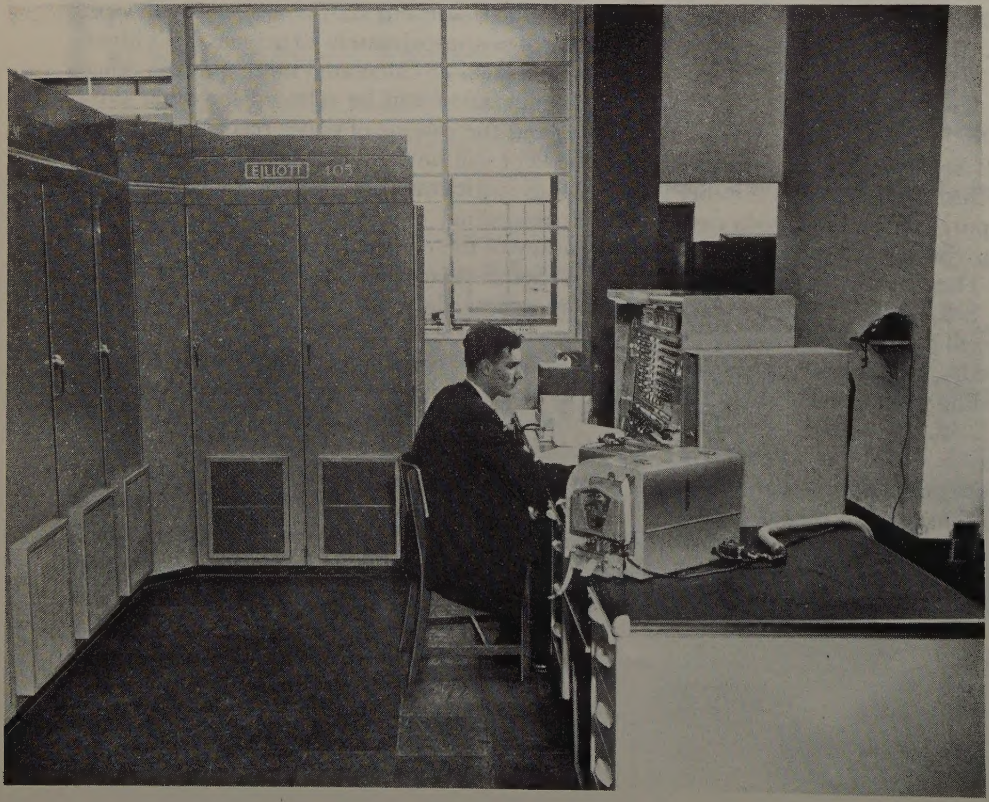
By P. A. Spooner

When Norwich Council decided to break new ground by installing a computer in the City Treasurer's Department, they had a clearly defined object—to develop faster and less costly ways of doing their clerical chores.

To-day, a great deal is heard about the value of employing computers in the more advanced fields of operational research and management control, and this may make the Council's objective seem a little pedestrian. Nevertheless, "electronic book-keeping" is still the main concern of businesses which have installed computers or are preparing to do so.

For Norwich Council it was a logical choice. Much of the work of a local authority is repetitive and runs on fairly rigid lines; certain records have to be kept in a form prescribed by Acts of Parliament. This means that, as a rule, the introduction of new methods or equipment is justified only if it enables the authority to get through a fixed quantity of work with less effort and expense.

Take, for example, the clerical tasks of rate collecting and accounting. It is hardly possible to improve the end-products of these—the demand notes and the rate book—or to attract new customers by offering a more efficient service. And while there is some value in obtaining



Norwich City Council's National-Elliott 405 computer

Mr. Spooner is with the National Cash Register Company Limited.

Data are recorded on 35-mm magnetic film

better management information on the collection of rates, this cannot be acted on in the way that a commercial firm would act on marketing reports. Rate accounting is, in fact, one of the straightforward but rather unwieldy clerical jobs which the Norwich computer has taken over. To-day, the whole of the rate book information —covering 47,000 properties—is stored and regularly up-dated on reels of magnetic film, while demand notes and other working documents are printed out automatically. This is a unique technical achievement in the municipal field. But on purely commercial grounds the most significant fact is that this work is now being done by fewer people.

The same applies to three other clerical routines which the computer is handling successfully:—

Preparation of interest warrants and tax deduction certificates for people who have loaned money to the Council.

Preparation of income tax and superannuation records for Council employees (as a prelude to taking over the full job of wage and salary accounting).

Settlement of bills and claims (later, all expenditures will be analysed for the purpose of budgetary control).

To some extent the Norwich operation cuts across the widely expressed belief that the capabilities of an electronic computer cannot be exploited profitably unless there are fundamental changes in working procedures and even in the content of the work. During the setting-up period, the Council were more concerned with fitting the machine to the jobs than with fitting the jobs to the machine. It was the adaptability of electronic data processing equipment, as much as anything else, that they were putting to the test. Their experience can be summed up in a few words. The machine, a National-Elliott 405, was commissioned in April 1957. The Council have used it as a "workhorse" because a "workhorse" is what they needed. And now, after two and a half years, they are able to reaffirm their original belief that by the time the machine comes to the end of its working life it will have produced cash savings amounting to many thousands of pounds.

How the project began

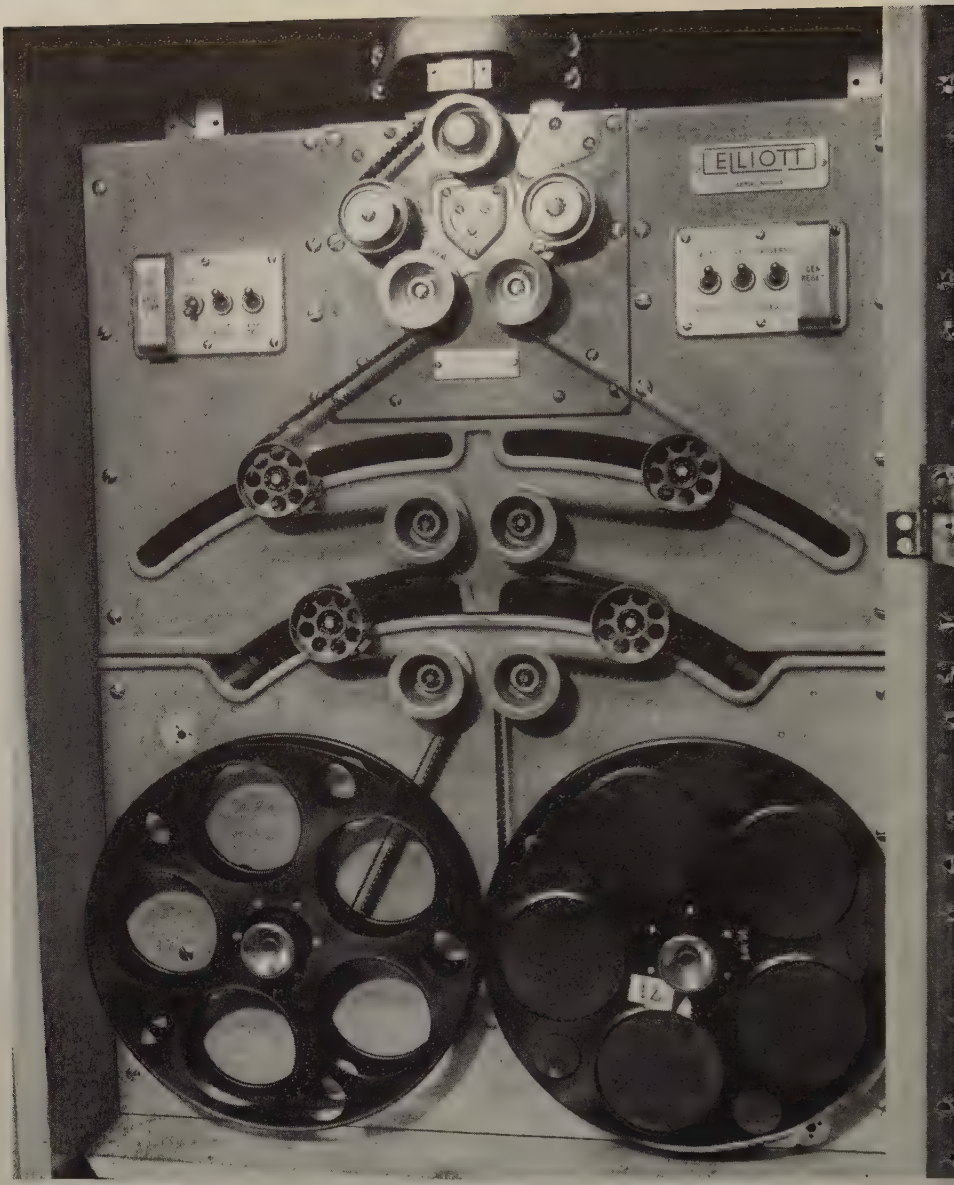
In 1949 the Council started to overhaul and centralize their clerical operations. After preliminary studies by a small staff committee, the long-term programme was made the direct responsibility of the City Treasurer. Most of the systems then in use were manual. The main exception was a punched-card installation, established in the 1920's and largely re-equipped after the war. This belonged to the City Engineer's Department, which used it solely for costing work. The equipment was taken over by the City Treasurer, together with the work it was doing and other jobs, such as invoice analysis and debtor control, were then put on to it.

A few years later, the Council decided that the time had come for a major advance in mechanization. They believed that in this way their administrative costs (while no higher than those of most local authorities) could be reduced considerably. The punched-card installation as it existed was not capable of handling large book-keeping jobs. Consequently the Council had to choose between completely re-equipping it or finding a different system.

Their requirements were defined by the City Treasurer as:—

"A system which records data and the movement of data, as in book-keeping. It must be capable of storing large quantities of data in a small space; and of allowing periodic (but not random) access for either reference or processing. It must also be capable of producing bills and payroll, and of analysing these for costing and budgetary purposes."

It was in order to meet these requirements that the Council turned to electronic computing and, in particular, the use of magnetic storage. Their decision to purchase a computer was en-



Magnetic film unit. Nearly 300,000 *computer words can be recorded on one reel of film*

dorsed by a team of independent consultants who were making a general organization and methods survey.

The equipment was delivered in February 1957, about 12 months after the order was placed. It consisted of:—

A National-Elliott 405 computer, with punched paper tape input and output. Two large-volume data storage units. (The 405 and its successor, the 405M, use sprocket-driven 35-mm film, coated with magnetic oxide, as a storage medium. One reel holds nearly 300,000 computer words.)

Two Compuprinters for off-line printing. (The Compuprinter is a character-printer, similar in principle to an electric typewriter but actuated by punched paper tape. It works at a speed of 15 characters per second.)

Paper tape punches and other ancillary devices.

The only significant additions since 1957 have been a 60-characters per second output punch (more than twice as fast as the original unit) and two improved models of the Compuprinter. The Norwich installation is, in fact, the smallest of the 20 National-Elliott systems which are now being used by commercial undertakings and government departments.

Its size was dictated by caution as well as by financial considerations. At that time, electronic data processing was largely unexplored territory. For a local authority—handling public money—there were special hazards in playing the role of pioneer. Although the Council had confidence in the computer and its magnetic storage units, they were not inclined to rely too heavily on fast output printing, then unproven; and it was for this reason that they chose the safe but relatively slow punched-tape system.

Now that the basic operations are running smoothly, the output side of the installation may be extended. This would enable better use to be made of the computer's capabilities. Nevertheless, the discipline of slow output has produced some unforeseen benefits.

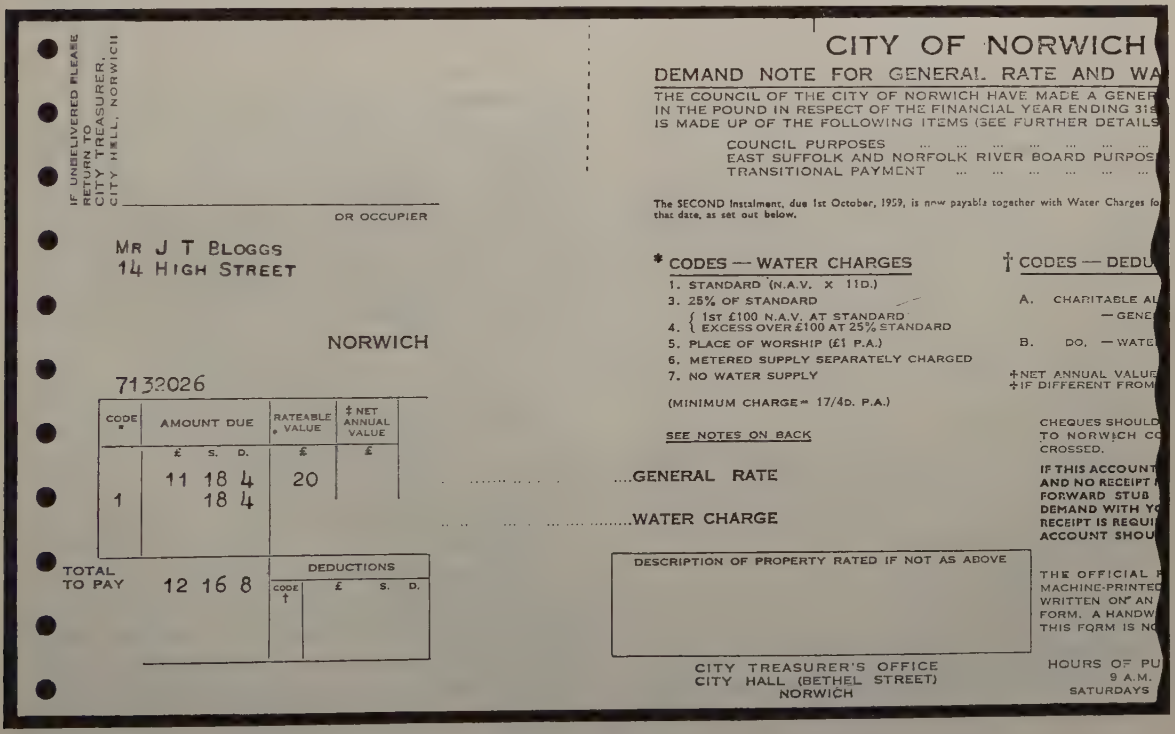
Rate demand note

To offset the fact that the Compuprinters lacked tabulating facilities, the existing forms had to be drastically redesigned (for example, the rate demand note was reduced in width and its perforated stub was replaced by a carbon copy). These alterations will still hold good if faster output units are introduced, whereas the need for them might have gone unnoticed if such facilities had been available from the start.

As soon as the computer was installed, the City Treasurer's Department began to set up the rate accounting operation. Their aim was to be able to despatch machine-produced demand notes at the beginning of the financial year. It was then that the need for caution became important. With no outside experience to draw on, the department could not afford to dispense with their manual system until it was quite clear to the Council—and to the district auditors—that the new system was functioning perfectly. This meant that they had to postpone the plan to integrate what were then two separate procedures—the general rate and the water charges. If an attempt had been made to integrate these in the first computer programme, it would have removed the protection obtained by running the old and new systems in parallel.

When the programme was run for the first time, the computer merely produced the output tapes from which the demand notes were printed in a subsequent operation. Six months later, the demand note routine was repeated and, in addition, the full contents of the magnetic films were printed out to provide the rate charge book. Also, cash posting was integrated with the computer system and for the first time a printed rate book (showing the position at the end of the six-month period) was produced. This was submitted to the auditors after it had been checked

Rate demand notes are printed by punched-tape operated Compuprinters



IF UNDELIVERED PLEASE
RETURN TO
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CITY HALL, NORWICH

OR OCCUPIER

MR J T BLOGGS
14 HIGH STREET

NORWICH

7132026

CODE *	AMOUNT DUE	RATEABLE • VALUE	‡ NET ANNUAL VALUE
	£ S. D.	£	£
	11 18 4	20	
1	18 4		

TOTAL TO PAY 12 16 8

DEDUCTIONS

CODE †	£ S. D.

CITY OF NORWICH

DEMAND NOTE FOR GENERAL RATE AND WA

THE COUNCIL OF THE CITY OF NORWICH HAVE MADE A GENER
IN THE POUND IN RESPECT OF THE FINANCIAL YEAR ENDING 31s
IS MADE UP OF THE FOLLOWING ITEMS (SEE FURTHER DETAILS

COUNCIL PURPOSES ... ...
EAST SUFFOLK AND NORFOLK RIVER BOARD PURPOS
TRANSITIONAL PAYMENT ... ...

The SECOND Instalment, due 1st October, 1959, is now payable together with Water Charges fo
that date, as set out below.

* CODES — WATER CHARGES

1. STANDARD (N.A.V. x 11D.)
3. 25% OF STANDARD
4. { 1ST £100 N.A.V. AT STANDARD
   EXCESS OVER £100 AT 25% STANDARD
5. PLACE OF WORSHIP (£1 P.A.)
6. METERED SUPPLY SEPARATELY CHARGED
7. NO WATER SUPPLY

(MINIMUM CHARGE = 17/4D. P.A.)

SEE NOTES ON BACK

† CODES — DEDU

A. CHARITABLE AL
— GENE

B. DO. — WATE

‡ NET ANNUAL VALUE
‡ IF DIFFERENT FROM

CHEQUES SHOULD
TO NORWICH CO
CROSSED.

IF THIS ACCOUNT
AND NO RECEIPT
FORWARD STUB
DEMAND WITH YO
RECEIPT IS REQUI
ACCOUNT SHOU

....GENERAL RATE

....WATER CHARGE

DESCRIPTION OF PROPERTY RATED IF NOT AS ABOVE

THE OFFICIAL
MACHINE-PRINTED
WRITTEN ON AN
FORM. A HANDW
THIS FORM IS NO

CITY TREASURER'S OFFICE
CITY HALL (BETHEL STREET)
NORWICH

HOURS OF PU
9 A.M.
SATURDAYS

against the manually produced rate book. After April 1958, the printing-out operation was simplified by compiling the rate charge book from carbon copies of the demand notes.

For the second half of the 1958-59 financial year, manual cash posting was omitted; instead, items were simply marked as "paid." With this advance, the manual system was, to all intents and purposes, superseded. Last April, it was abandoned altogether and the water charges were brought into the computer system as originally planned.

The complexity of the operation can be gauged by the fact that the City of Norwich has about 25,000 individual ratepayers, 47,000 rated properties and 47,000 water consumers. During the setting-up period, the basic information on each of these had to be punched into paper tape and then transferred to magnetic film. Altogether, the data occupy nine 1,000-foot reels—representing a total of approximately 2½ million computer words.

The magnetic films are not permanent stores. Whenever one of them is put through the computer, everything on it—whether up-dated or not—is copied on to a second film. The original records are not altered in any way; nor are they erased until the information on the second film has been processed during the next computing run and the results written on yet another film. This system of working ensures that accumulated records are never destroyed or garbled as a result of faults in the equipment or careless operation.

Arrangement of data

For the rate procedure the films are actually divided into two sets, dealing respectively with occupiers and owners. The former is the main set and contains the following information on every rated property in the City, excluding Council houses:—

- Reference number
- Address
- Name of ratepayer
- Reference number of the owner in cases where the rates are not paid by the occupier
- Net annual value
- Type of water charge
- Rateable value, and
- Description of the property.

The purpose of the second set of films is to group together all properties for which one owner has undertaken to pay the rates. The reference number of the owner provides a cross-reference to the data on the "occupier" films.

The first operation in the half-yearly cycle is the preparation of demand notes. For this, the current rate in the pound is punched into a short length of paper tape. This is read and the data stored on the computer's magnetic drum together with the programme of instructions. Then the first "occupier" film is placed on one of the film units. The computer considers each property in turn, calculates the rate due, and punches all the information which must appear on the demand note into paper tape. Simultaneously, the up-dated information is written on a blank film in the second film unit.

Printing demand notes

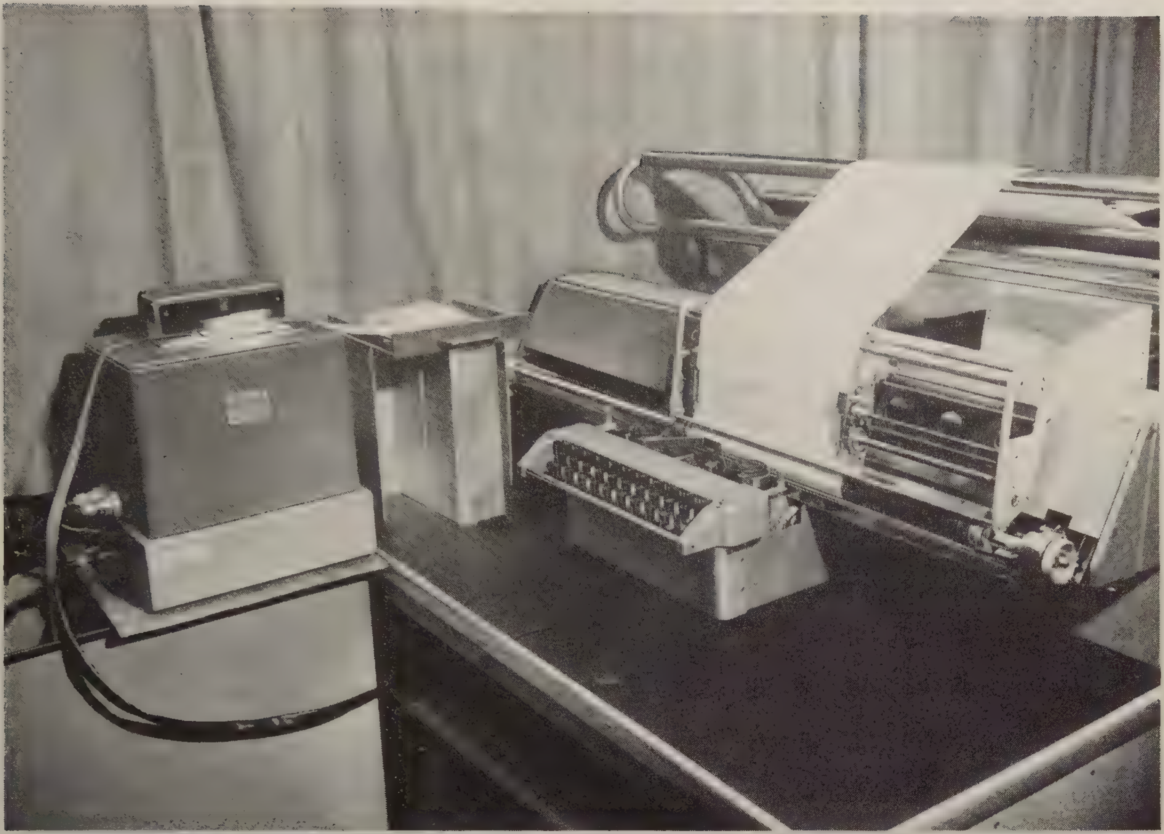
The same procedure is repeated with the other films. After this, the output tapes are put through the battery of Compuprinters which automatically print the demand notes on continuous stationery. Finally, the sets of forms are separated and the top copies are despatched to the ratepayers. The carbon copies of the demand notes are then collated and bound into the rate charge book. At fortnightly intervals, this basic information is up-dated in two ways:—

Cash postings. When an occupier or an owner pays his rates a receipt is issued. Every day a batch of receipt stubs is passed to the computer department, where the information on them is punched into paper tape. This information is then sorted into film order by the computer and posted to the appropriate accounts.

Amendments. These occur when properties change hands or when rateable values are adjusted. Details of each amendment are recorded manually on a slip pre-printed with punching and control symbols. These are then hand-sorted into film order (that is, the order in which properties are stored on the films) before the computer input tape is punched.

In time, these fortnightly operations will be integrated. One reason why they are done separately, at present, is that the City Treasurer's Department have been anxious to avoid the difficulties which might have arisen if they had tried to pack too many things into one programme.

The next operation in the cycle is the preparation of final demand notes. On the appointed date, the computer goes through the films scanning the details of each property and owner in turn. Where there is an outstanding debt, the appropriate information is punched and printed



A Compuprinter assembly. The punched paper tape reader is on the left

out. After the prescribed time has elapsed, a court summons list is produced in much the same way.

Throughout the accounting period the computer produces fortnightly records of all postings and amendments, and also summarizes the contents of the films for accounting purposes. Finally, the rate book is obtained by making tabulations of all basic data and transactions

Rate accounting is a task which, in theory, could be simplified considerably by applying the principle of control by exception. As the City Treasurer, Mr. A. J. Barnard, says:—

"We record an immense quantity of figures which, because they are normal, really don't need recording at all. God bless the ratepayer who pays on the nail, but he is not so interesting as the one who nearly goes to prison"—which is another way of stating that much computing time could be saved if interim print-outs were restricted to first demand notes, final demand notes, and the court summons list.

Unfortunately, theory and practice have to diverge because without up-to-date printed records it would be extremely difficult to handle the steady stream of enquiries about individual hereditaments. The situation is never static; and solicitors and others are constantly seeking information on properties which have been reassessed or are changing hands. It would be no use applying control by exception if the time-savings in the main routines were promptly eclipsed by the increased cost of dealing with the exceptions that occur outside the paid-or-not-paid pattern.

However, it may be possible to streamline the final printing-out of the rate book by eliminating names and addresses and relying on the reference numbers to identify details of transactions with the more comprehensive data provided in the rate charge book. If the two books were always treated as an entity, the requirements of the Act governing rate book procedure might be satisfied.

Although the rate procedure has received more attention than anything else, the computer has progressively absorbed other tasks. These are described very briefly below.

Bills and claims. This operation is divided into two parts: the production of advice notes and cheques for creditors and the posting and analysis of payments.

The first part has been running for some time and the second part was put into operation a few weeks ago.

Like the rate procedure, the settlement of bills and claims is a fairly complex book-keeping operation, involving a large number of documents. The Council have about 6,000 creditors and every fortnight one or more payments are made to about 600 of them. This represents a total of at least 100,000 invoices per annum. In the past the monthly bills from each creditor had to be collated and totalled manually before they were passed to the punched-card department for processing. Now the whole operation is done on the computer.

However, the departments spending the money are responsible for a certain amount of preparatory work. Their main task is to convert the invoices received by them into coded data which can be punched directly into paper tape; for this purpose they use hand-written slips attached to the corresponding invoices. Each batch of unsorted invoices is totalled on an adding-listing machine.

These batch totals are punched into the tapes. They are used as control figures when the tapes are put through a test programme. This totals all items electronically and also ensures that the encoded data are acceptable to the computer.

Batches of invoice data are handled in this way three times a week. The final operation —done fortnightly—involves two consecutive computer runs. During the first of these the machine produces the punched tape from which the cheques are printed (one for each creditor, irrespective of the number of invoices he has submitted). During the second run, it produces the advice notes tape. The double run is unavoidable at present because the computer has only one output punch.

With the budgetary part of the procedure in operation, the weekly payments are now listed under about 4,000 budget headings. Later, this work will be extended by using the computer to prepare detailed analyses of past expenditure and thus assist in setting budget standards against which the current figures can be checked automatically.

Both the standard and the cumulative figures for the current period will be stored on magnetic film. During the weekly print-outs only exceptional items will be drawn to the management's attention. This will certainly exploit the computer's powers of discrimination more fully than the other applications.

Mortgagee's records. This twice-yearly job, covering about 3,000 mortgages held by the Council, was started in March 1959. It consists of two distinct operations: first, the preparation of interest warrants and tax deduction certificates; and, secondly, the preparation of a maturity schedule for controlling the Council's loan transactions.

Wages and salaries. The maintenance of employees' income tax and superannuation records is also a twice-yearly job. Formerly done on punched-card equipment, it was transferred to the computer with little or no change in procedure.

Wage calculations by computer

Soon, however, the computer will take over the much larger job of wage and salary accounting, which involves 600 staff employees, 800 teachers, and between 2,500 and 3,000 hourly-paid or part-time workers. The present payroll system is based on the use of hand-written wage sheets. The computer operation will follow a fairly orthodox pattern. Permanent data and cumulative records of pay, tax deductions, etc., will be stored on magnetic film; new information for each pay period will be punched into paper tape. The machine will produce individual payslips as well as a printed payroll. In addition, the computer will analyse the information contained in the payroll.

Utilization. At present, the machine is switched on for between 80 and 90 hours per week—50 per cent of the theoretical night-and-day maximum. For nearly two-thirds of this period it is doing productive work: the remainder is devoted to programme development and routine testing.

The regular computing schedule will be virtually complete when the machine takes over the costing of such activities as the maintenance of roads, houses, public buildings and vehicles, the erection of houses, the disposal of sewage, and general works.

Even then, it is unlikely that the computer will be fully occupied. As experience is gained, the existing jobs are progressively speeded up. For example, the production of demand notes and the rate charge book now takes only 45 hours of computing time, compared with 191 hours, 127 hours and 122 hours in three previous half-years—this when the water charges were not included. The trend will undoubtedly continue, particularly if the output facilities are improved.

However, the Council are not going to make a fetish of machine utilization. They believe that it will always be an advantage to have a certain amount of spare capacity for dealing with exceptional conditions and one-off jobs. On the other hand, efforts will be made to fill any sizeable gaps in the work schedule.

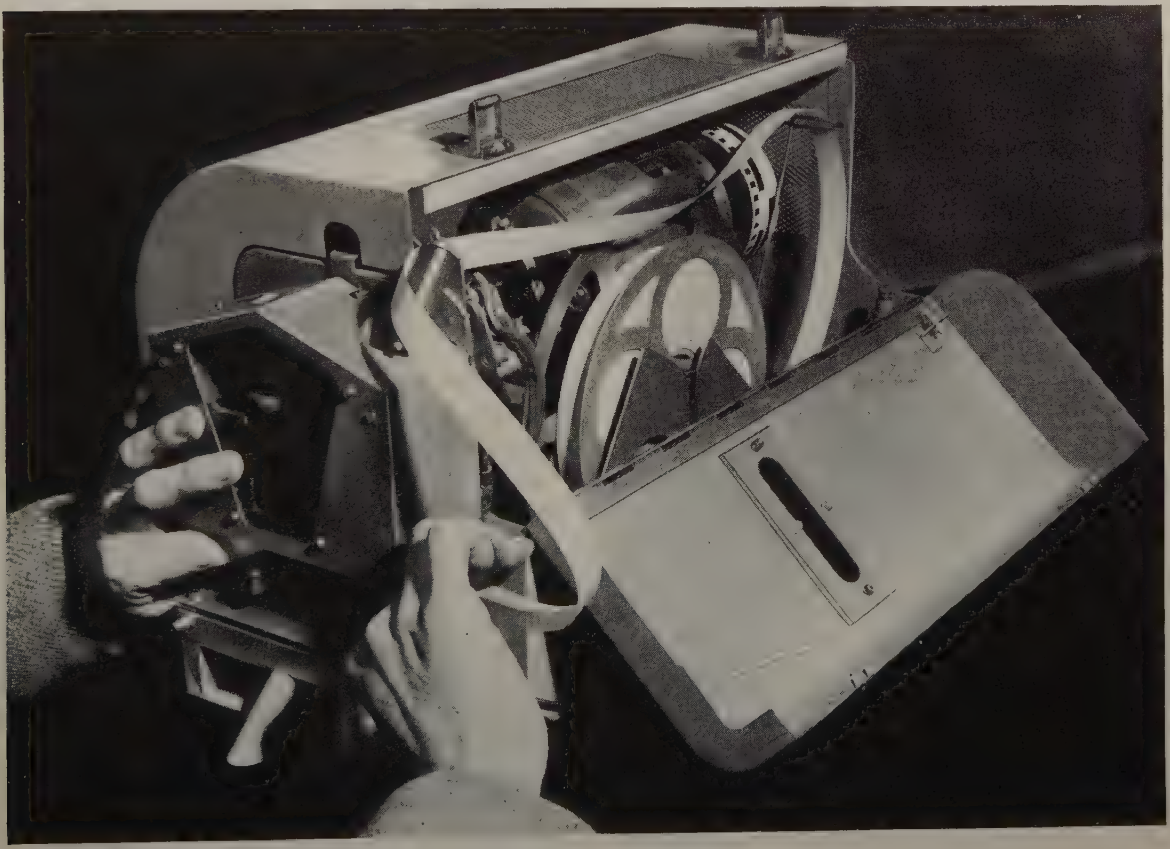
One possibility is that the Council will enlarge their service bureau operations—the scheme under which others use their facilities. So far, this has been run on experimental lines. Nevertheless, it has produced some useful revenue; nearly £2,000 in each of the two years since the computer was installed. This is a creditable performance in view of the fact that the Council have been charging the unusually low time-hire rate of £15 per hour.

Right from the start the computer has been doing a regular weekly job for the Council's stockbrokers. This involves the analysis and tabulation of share market information. The original data arrive by train on Friday afternoons, and the tabulated results are despatched in the same way on Saturday mornings. Other jobs, mostly non-routine, have been carried out for a local firm of construction engineers. In both cases the clients wrote the programmes. Future operations include the servicing of a weekly payroll for a local firm with only about 120 employees.

Staff requirements

Because they were pioneers, the Council had to grow their own programmers and operating staff. In one respect they seriously under-estimated the scale of the work and thus made the now classic error of too little and too late. The first programmer was appointed in April 1956—two months after the computer was

Results of computations are punched into paper tape. A blank tape being threaded through the computer output punch



ordered and only ten months before it was delivered. A second programmer was appointed in November 1956, and a third in June 1957. By then, however, there was a nasty backlog of work. As a result, the team were continually working against the calendar, and expediency, rather than maximum efficiency in programming, was often the decisive factor.

Introduction of direct rating and industrial re-rating, plus a 20 per cent reduction on commercial and shop properties, increased the difficulties. This affected the original programmes as well as necessitating many thousands of amendments to the information already stored on magnetic film. At the same time, changes in the team, caused by promotion and resignations, seriously upset the continuity of the work.

Programming staff

At present, the team consists of: a senior programmer who already possessed some experience when he joined the City Treasurer's Department (although this had been gained on another type of computer); a member of the staff who received his basic training on one of the computer manufacturer's programming courses; a youngster recruited straight from school, where he had done extremely well in mathematics (he has been trained entirely on the job).

The Council found by experience that it is of great value to have at least one person with practical experience of accountancy problems. Even with formal training on a four- or five-week course, it takes an average person at least six months to develop some usefulness as a programmer, and between one year and 18 months to attain a reasonable level of competence. The thing to look for when picking youngsters for this work is a logical turn of mind, rather than high academic qualifications.

A fully qualified accountant handles the organization and methods side of the operation. Experience has shown that one O and M man can successfully keep three programmers busy if he is on his toes. In any case, should their respective jobs get out of step, the senior programmer can temporarily turn his attention to method studies.

The O and M man has been on a programming course and is thus able to appreciate the others' problems. Between him and the programmers there is, in fact, very close liaison. The team have found that it is impossible to place their jobs in watertight compartments—in this field one man's work never gets to the stage where it can be handed over, as a complete package, to someone else. For the same reason, no attempt has been made to split up the tasks of writing programmes and putting them into machine language.

The operation and servicing of computing equipment is carried out by two engineers. As a safety measure, their duties have been made interchangeable.

Preparing data

Input tapes are punched by three girls. Two are employed on this work full time; the third is brought in only during busy periods. All have been trained in the City Treasurer's Department; the only basic skill they needed was touch-typing. However, since accurate punching is the key to accurate computing, the department have taken pains to give them a good picture of the whole operation. This ensures that they are more likely to spot silly mistakes in the material which they are handling.

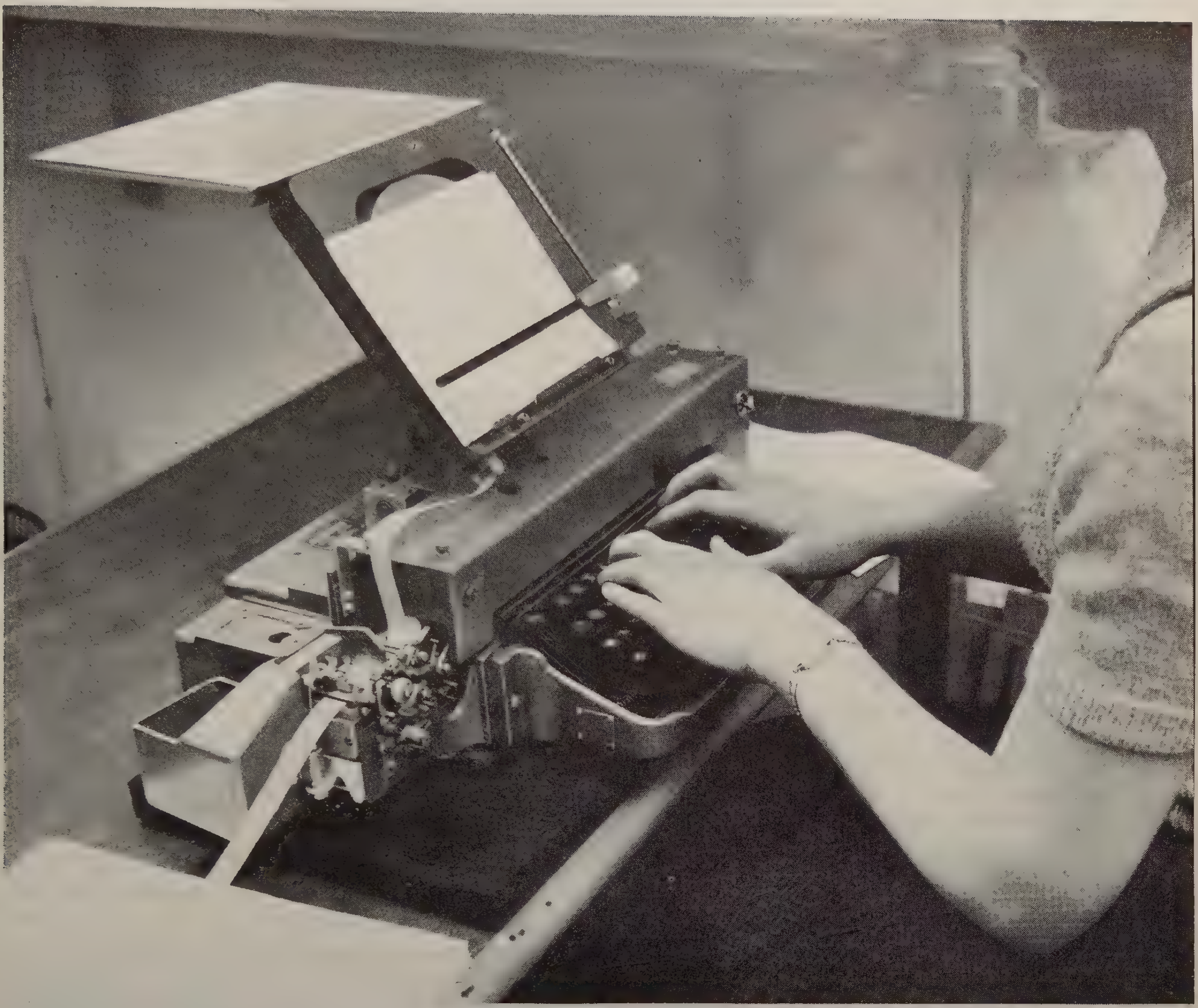
In any event, all tapes are very carefully checked before they are used. For this purpose the original tape is run through a verifier while the source information is re-punched (by a different operator) into another tape. If a discrepancy occurs, the keyboard of the machine immediately locks.

Seeing that their main objective was to save clerical labour, the Council have paid a lot of attention to the human relations aspect of the computer operation. As soon as the order was placed (and before rumours had a chance to spread) the City Treasurer called all members of his staff together and gave them a full explanation.

Staff reorganization

He emphasized that, because of the current shortage of clerical workers, nobody's livelihood was endangered by the computer, and gave assurances that permanent staff who were displaced by it would be offered employment on other duties, all redundancies being offset by normal staff wastage.

After the machine had been installed the whole staff was allowed to inspect it during working hours. This opportunity was then extended to members of other departments and about 80 per cent of them took advantage of it. At the same time, the local press was given ample facilities for obtaining reliable information on the project, thus avoiding the sort of speculation



Input data for the computer being punched into 5-channel paper tape. Data transcribed by one operator are verified by a second operator. Three girls are employed on this work—two full-time, one part-time

and science-fiction news reports which might have had a bad effect on the morale of Council employees.

So far, the staff savings have been fairly modest; only ten out of the 110 people employed in the City Treasurer's Department. Further reductions will be made when the budgetary part of the bills and claims job gets into its stride and, later, when the full payroll and costing procedures are absorbed. The elimination of the punched-card equipment, now costing about £1,000 in rental charges, will also produce an appreciable financial saving.

Although the computer is estimated to have a working life of 15 years, the Council have decided to amortize the capital cost over the relatively short period of six years. Thus the financial position will improve in 1963.

Altogether, the net savings are expected —rather conservatively—to reach about £7,000 per annum when the computer programmes are fully developed, even if the time-hire work remains at the existing level. This is a substantial sum in relation to the size and relatively low cost of the installation. It is, moreover, a realistic target, and for this reason the Council prefer to regard their computer as a strictly business-like venture, rather than as an important piece of pioneering work in the field of municipal administration.

Letter writing by numbers

Automatic machine that types over 120 individually composed letters a day

An automatic typing machine, the Auto-Typist, can operate any manual or electric typewriter, produce as many as 20 individually typed letters an hour and relieve the staff of the burden of dictating replies to routine correspondence.

Letters are composed by quoting a list of numbers which identify standard paragraphs. An operator then sets the machine to type these paragraphs in the desired sequence simply by pressing buttons. The machine is controlled by a perforated band of paper. Costs range from £430 to £1,125 exclusive of the typewriter

PROBABLY it is not realized how much of the information contained in a business letter is repeated many times in the course of a week, although in slightly different contexts. At present, of course, it is the general practice to dictate and type each letter separately because of minor variations needed in individual paragraphs or alterations in the sequence in which the paragraphs are to be presented. In some cases a standard letter is manually typed to avoid sending an obviously duplicated copy.

Before the war a machine was designed and built that could operate a mechanical typewriter entirely automatically and produce individually typed standard letters. Since then, the appearance and performance of this machine, called the Auto-Typist,* have been improved. Nowadays the speed of operation is limited only by the rate at which the typewriter key action will function correctly. Also the method of selecting the paragraphs to be typed has been modified and a simple push-button control panel is now provided.

The information to be typed is represented as a sequence of punched holes on a wide band of paper. This perforated band is wound on to a spool which is fitted to the machine. The band passes over a pneumatic sensing head and, as it is played back, every time a hole is detected a mechanical linkage pulls down one of the keys of the typewriter, causing the appropriate character to be printed on the paper. The device is an adaptation of the pneumatic-type mechanism originally designed to operate a pianola.

It should perhaps be stressed that the Auto-Typist is the name given to the mechanism for operating the typewriter. Any design of manual or electric typewriter can be controlled. A direct but simple mechanical connection is made between the keys of the typewriter and the Auto-Typist, and all the control circuits are contained within a small desk unit upon which the typewriter stands. The complete assembly occupies the same space as a typist's desk. Electric power needed to drive the unit is drawn from the standard mains supply.

When used continuously, an Auto-Typist can produce between 120 and 140 letters a day depending, of course, upon the length of the letters. This output is said to be approximately three times greater than that of an average typist. In addition, as the machines are automatic in operation, it is possible for one operator to control up to four machines.

Preparation of circular letters

Several versions of the Auto-Typist, of varying complexity and capacity, are produced. The simplest are Models 5600 and 5620. The former is only suitable for operating electric typewriters, while the latter can be used in conjunction with either manual or electric machines.

Both these Auto-Typists are intended to type one complete letter automatically and repetitively—for example, circulars and sales promotion letters. The operator places the letter

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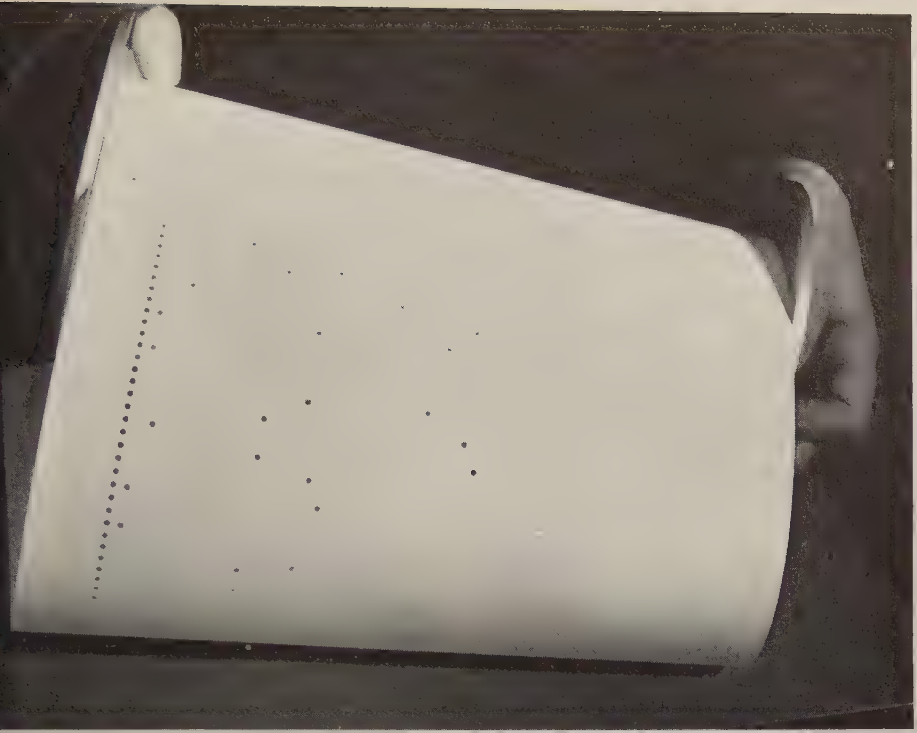
*Auto-Typist machines are marketed in Great Britain by the British Equipment Company Limited, Ixworth House, Ixworth Place, London, S.W.3.



The perforated band that controls the operation of the Auto-Typist

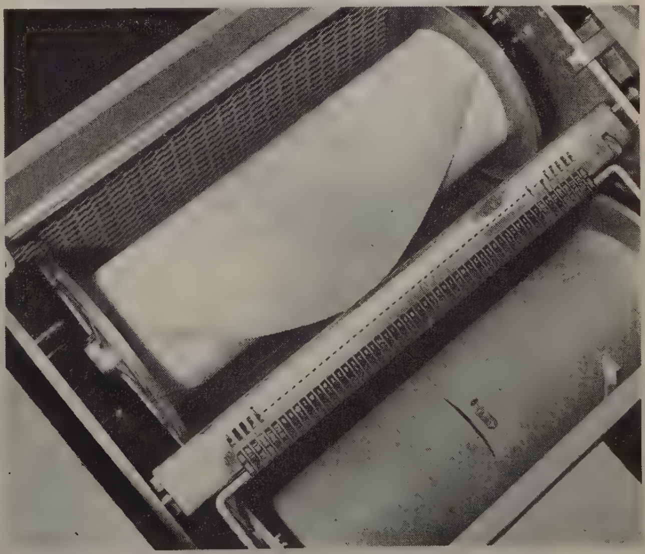
paper in the typewriter, types the name and address, date and the greetings at the beginning of the letter and presses the Auto-Typist's "start" button. The remainder of the letter will then be typed completely automatically under the control of the roll of perforated paper fitted in the reading unit of the machine. When a different letter is to be typed the roll is removed and replaced by another. Rolls can be changed quickly; the job takes less than a minute.

An average typist operating a group of Auto-Typists can produce up to 400 individually typed letters in a day and be sure that no typing errors have been made in the body of the letter.

Although the machines just described have a high rate of output, they are only suitable where

(*Left*) *Fitting the perforated band*

(*Below*) *The pneumatic sensing head*



one letter requires to be repeated many times. Another and operationally more flexible version of the Auto-Typist is produced for applications where similar standard information is included in a large number of letters, but no two letters are identical. These machines are provided with push-button selector panels.

Letters of this sort are composed by selecting the appropriate paragraphs from a range of standard paragraphs. Up to 250 lines of text can be recorded on one roll of perforated paper. This is usually sufficient for 30 separate paragraphs. Each paragraph is numbered and the Auto-Typist is provided with a panel containing 30 numbered buttons, one for each paragraph.

To operate the machine the typist winds the letter paper into the typewriter and types the name, address, date and greeting at the beginning. She then selects the paragraphs to be typed by depressing the appropriate keys on the selector panel. When the "start" button is pressed the Auto-Typist will feed the paper band at high speed past the pneumatic reading head until it comes to the first of the selected paragraphs. The speed of paper feed is reduced to the reading speed and the paragraph is typed. The perforated band is then moved forward automatically to the portion containing the next selected paragraph. This is then typed. Proceeding in this way, the machine produces a letter containing all the desired paragraphs. When the next letter is typed a different set of paragraphs can be selected, or a different sequence, and in this manner a large number of individual, yet unique, letters are prepared from a selection of standard paragraphs.

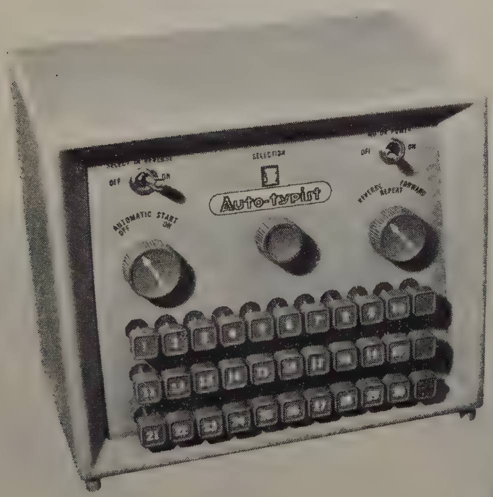
Such machines reduce the labour of preparing replies not only for typists, but also for executives. Instead of time being wasted in dictating what are virtually standard letters, the executive need only quote the name and address of the person to whom the letter is to be sent together with the numbers of the paragraphs to be typed.

Normally the paragraphs are typed in the sequence in which they are recorded on the roll. However, if a paragraph bearing a lower number is required to follow a higher numbered paragraph, the roll can be rewound.

Models available

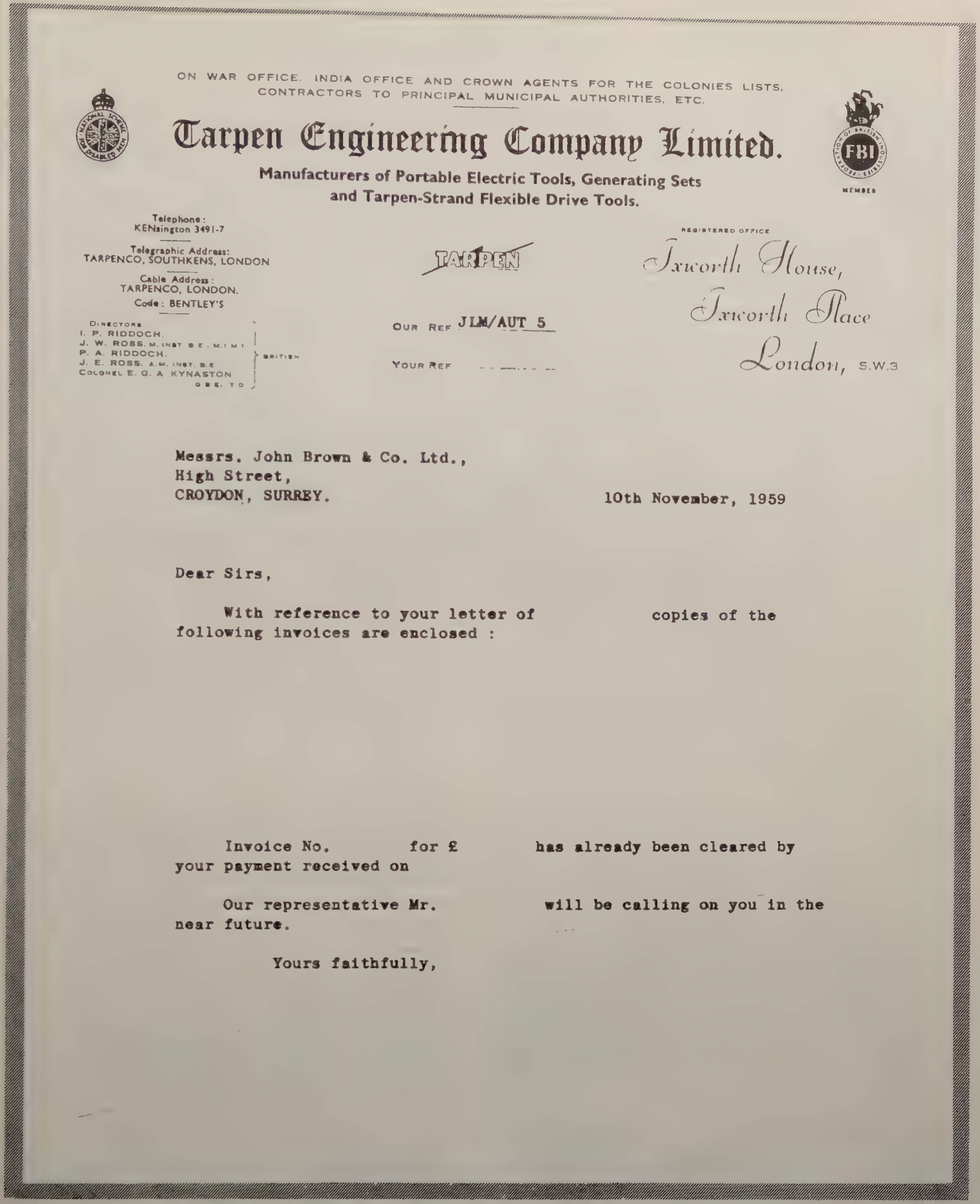
Models are available with control panels containing 30, 50 or 100 selector buttons. The 100-button machine is really two Auto-Typist units connected to one typewriter. The two units are housed in a single desk. The machine has two 50-button selector panels and is fitted with two pneumatic reading units. Consequently any of 100 paragraphs can be reproduced. Up to 500 lines of type can be recorded on the two perforated rolls.

Where a library of perforated rolls is kept, the information recorded on each one can be arranged to cover particular forms of correspondence needed by particular departments, such as sales, purchasing, accounts and publicity.



(Above) Control panel of a 30-button machine

(Right) Any sequence of 100 paragraphs can be selected on this dual machine



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OUR REF JLM/AUT 5

YOUR REF

Messrs. John Brown & Co. Ltd.,
High Street,
CROYDON, SURREY.

10th November, 1959

Dear Sirs,

With reference to your letter of copies of the following invoices are enclosed :

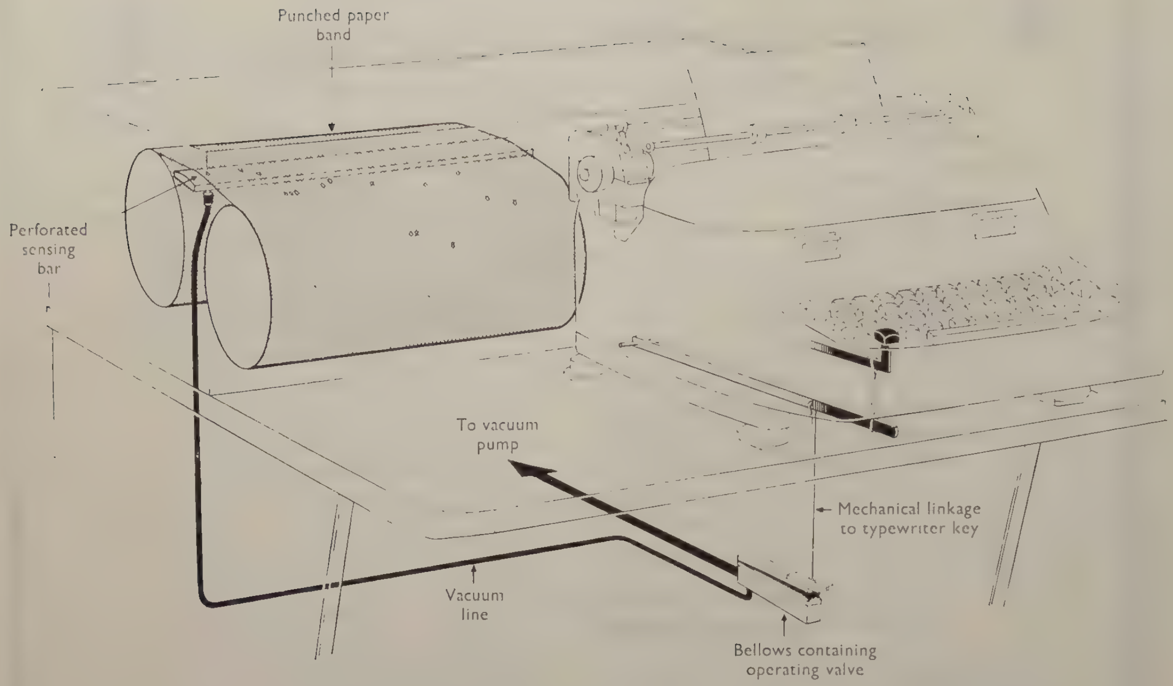
Invoice No. for £ has already been cleared by your payment received on

Our representative Mr. will be calling on you in the near future.

Yours faithfully,

A letter incorporating a number stops where variable data are entered manually

Although the Auto-Typist is connected to the typewriter mechanically, this does not prevent a typist using the typewriter in the conventional manner. Hence non-repetitive facts and figures can be included in the body of a standard letter or paragraph. A special code hole is punched in the tape which will stop the Auto-Typist when the desired point is reached. The operator then types in the required data and restarts the Auto-Typist, which completes the paragraph. Names, addresses, prices, quantities and invoice numbers are typical of the variable data that are entered in this way. One operator can control two or three Auto-Typists used for this type of work.


Punched paper band
Perforated sensing bar
To vacuum pump
Mechanical linkage to typewriter key
Vacuum line
Bellows containing operating valve

Mechanism of the Auto-Typist shown diagrammatically

Prices of models range from £430 for the simplest Auto-Typist (Model 5600), a machine suitable for typing a large number of identical letters, to £1,125 for the dual Auto-Typist.

Of all the models in use perhaps the 30-button unit (Model 5630) is the most popular as this is a versatile machine with sufficient capacity for the general run of business correspondence. This machine costs £598, or £630 when adapted to operate both manual and electric typewriters. These prices, of course, do not include the cost of the typewriter itself.

In this connection it should be noted that it is preferable to fit an electric typewriter to an Auto-Typist rather than a manual machine, because electric typewriters can work at higher speeds. An Auto-Typist can operate a manual machine at speeds up to 100 words per minute, but, because of their faster response and lighter touch, modern electric machines can be controlled at speeds between 140 and 165 words per minute. Obviously an improvement in the basic speed of 40 per cent gives a greater return on the capital invested.

A 15-year life is quoted for an Auto-Typist, although construction is so simple that, with careful and regular maintenance, there is no reason why the machines should not last considerably longer. It has already been stated that a combined pneumatic mechanical system is used. This simplifies servicing and any competent mechanic can maintain these machines.

The band of paper on which the data to be typed are recorded is approximately 12 inches wide. Spaced across the paper are a number of tracks (about 50) and a hole punched in a track will cause one function to be performed. Usually 46 tracks are made available to operate the keys on the typewriter, the remaining tracks controlling the operation of the tape-reading unit. On electric machines the carriage return and line spacing is, of course, initiated by the depression of a key; control in this case is therefore straightforward. On manual machines the lever mechanism that performs this action is connected to the Auto-Typist by a special linkage.

The way in which the Auto-Typist operates is this: the band of paper passes over a bar that contains a perforation to match every track on the paper. This bar is identical with the perforated bar on a pianola. From each perforation there is a tube to a small set of bellows to which a lever is attached. A rod extends from the end of this lever and is hooked round the arm of one of the keys of the typewriter or, alternatively, is connected to another lever which is, in turn, directly linked to the typewriter key. A vacuum pump draws air from each of the tubes.

As the paper band passes over the perforated bar, the suction created in the tubes causes the paper to be drawn into close contact with it. When a hole in the paper band passes over a perforation, the vacuum in the particular tube collapses momentarily. This causes a valve to open and connects the bellows—the one the tube controls—directly to the power of the vacuum pump. The bellows contract and pull down the lever which, in turn, operates the key of the typewriter. Then, as soon as the hole has passed beyond the perforated bar, a spring restores the bellows to their original position and everything is now ready for the next character to be typed.

Mechanism

This extremely simple mechanism is illustrated in the accompanying diagram. A similar pneumatic system is used to control the operation of the paper feed unit. Code holes identify the beginning of each paragraph and when a special end-of-roll code signal is detected the unit rewinds the roll to the starting position. Rewinding takes 1¼ minutes.

Paper bands are prepared on a perforating punch. This consists of a paper feed unit, a standard typewriter keyboard, and a line of mechanically operated punches. Each key is connected to its appropriate punch and, as the information is transcribed from the original document, holes are perforated in the paper band. Keys are also provided to record the special code holes that control the operation of the paper tape reader.

It does not take much longer to perforate the text of a letter in a paper band than it does to type the actual draft. In fact, it is possible to link an electric typewriter to a perforating punch so that, as the draft is typed, a perforated band is prepared simultaneously.

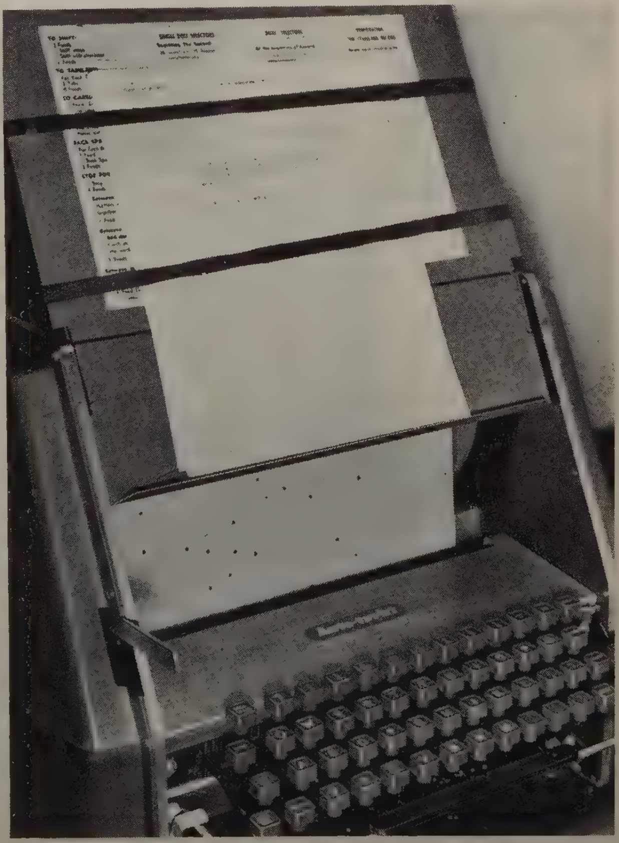
In large Auto-Typist installations it may be desirable to have duplicate copies of perforated rolls in order that more than one machine can type the same letter. For this purpose a re-perforating punch has been developed which rapidly and accurately produces copies of original rolls.

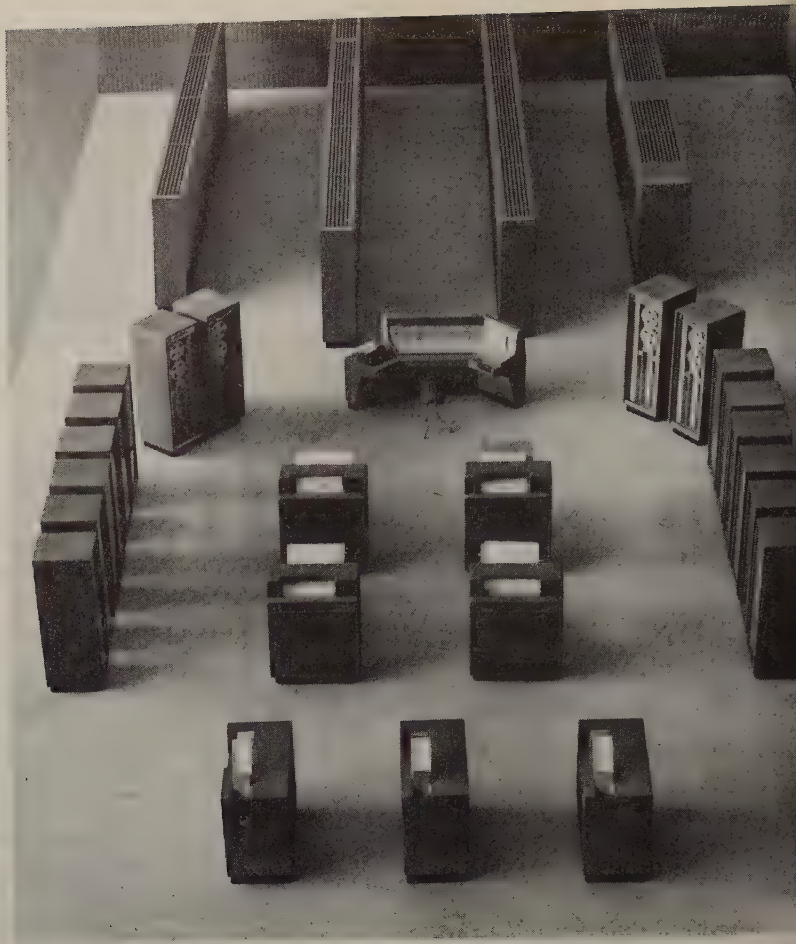
Normally it does not pay a company to own a perforator, which costs £165, unless a large number of Auto-Typists are used and the information recorded on the rolls is being changed fairly frequently. Consequently the British Equipment Company Limited operate a roll preparation service. For this a charge is made of 1s. a line. It would cost, therefore, £12 10s. to prepare one complete roll containing 30 standard paragraphs. Each roll has an unlimited life because wear is negligible and, provided the band is stored carefully, many thousands of letters can be prepared from the same roll.

One final but very interesting application of the Auto-Typist is the preparation of foreign correspondence. Once the required standard paragraphs have been correctly translated and coded, letters in the desired foreign language can be prepared quickly, accurately and economically, merely by pressing the appropriate selector buttons—this by an operator who has no knowledge of the language, thus avoiding both the possibility of mistakes and the special fees charged for typing foreign language letters. Also an executive, with no knowledge of the language, can compose letters from the standard paragraphs merely by quoting a list of numbers.

By combining the ability to incorporate variable data with standard information the Auto-Typist is a versatile letter-writing machine, capable of tackling much of the routine correspondence associated with commercial work.

Paper bands are prepared on this perforating punch





Model of a typical Gamma 60 data processing installation

Gamma 60

a new concept

Built by the Compagnie des Machines Bull, in Paris, the Gamma 60 data processing system embodies a new concept in computer engineering. As a result, several unrelated programmes can be run simultaneously on the one machine. Scientific, engineering and commercial calculations can all be performed at the same time. By the addition of more units, the system can be extended indefinitely to match the demands made upon it.

Nine Gamma 60 installations have already been ordered and the first is due to be delivered early in 1960. Included among the customers are three insurance companies, two banks, the French Railways and the Belgian Telephone and Telegraph service. The philosophy behind this novel design and the various units of the system are described in the following article

GAMMA 60 represents a significant departure from what might be called the conventional path of computer development. From the user's point of view, the most remarkable feature of the machine is that several unrelated data processing procedures can be performed simultaneously. Payroll, stock control, sales analysis, engineering design problems and test programmes can all be run concurrently. And when the programmes for these various jobs are being written, it is not necessary to make any allowances for the fact that the jobs may or may not be run together: each programme is created in the conventional way, as an independent procedure.

Another feature of great interest to the user is that, at any time, additional units can be attached to the system to increase its capacity. Further, there is no practical limit to the number of units that can be included in one system and operated simultaneously. Perhaps, however, it is as well to point out that this does not mean that a start can be made with an extremely small inexpensive system which is then progressively extended. The smallest Gamma 60 installation that it would be worth while operating costs about £500,000. By modern standards the Gamma 60 is a medium to large data processing installation.

Development of the computer

The easiest way to understand the design philosophy behind this system is to consider, first, the history of the electronic digital computer. Originally computers were built solely as high-speed arithmetical calculating machines. They were used on scientific, engineering and such military problems as ballistic calculations—cases where a vast number of arithmetical operations were performed on small quantities of input data. The predominant characteristics of these early computers were that they had fast arithmetic units, slow input data reading units and equally slow output data recording units. Also, only one problem was handled at a time and each step in the problem was performed in strict sequence. They were serial machines. This meant that, while data were being read into the information store, the arithmetic unit and the majority of the other components were idle.

This was not a serious impediment at that time, because the slower units were used infrequently, so only a small proportion of the total available computing hours was lost. However, when other types of engineering problem were tackled, and also when the first attempts were made to process commercial data, extended calculations of the type described were not needed. Instead, more data had to be read in, fewer calculations performed and more results obtained. Consequently, the amount of work that could be done depended primarily on the speed with which data could be fed into and out of the machine. As these speeds were low, the performance of the early computers suffered.

Two obvious developments stemmed from this situation. First, computer operations were overlapped as far as possible. For example, as information was being read, say, from one punched tape, the answer to a previous calculation was being punched in a second tape. Secondly, the actual speed of operation of the data input and output units was increased. Punched paper tape at that period was read at 30 characters a second; nowadays it is read at 1,000 characters a second. However, there are obvious limits to which operating speeds can be raised, and the rate at which the fastest reader can obtain information from punched tape or punched cards is still slower, much slower, than the arithmetic unit can handle it.

About this time magnetic tape arrived on the scene. This alleviated the situation to some extent, because data could be recorded on magnetic tape or read from it at speeds in excess of 30,000 characters a second. However, in order to use magnetic tape for this purpose, it is necessary to have transcription units to convert input data recorded in paper tape or punched cards into pulses recorded on the magnetic tape. Also, at the end of a data processing run another transcription unit must perform the reverse operation and translate magnetic pulses into printed characters or punched holes.

This is the present state of the computer art and the majority of the computers on order, or being delivered, use this technique for getting data into and out of the machines promptly. Unfortunately, this solution has its snags. Although the computer is now used more efficiently, it is surrounded by a number of complex satellites—the transcription units. Not only are these expensive, but also they are not always fully employed.

Utilization

They are expensive because, in effect, they are small, simplified, special-purpose computers. Consequently, the original problem reappears—how to utilize efficiently costly items of equipment. The same also applies, though to a lesser extent, to those systems that rely on high-speed reading and printing units connected directly to the computer. These units are not cheap to buy and they are not utilized to the full.

Computer designers appreciated that this situation would arise and the solution proposed by the engineers of the Compagnie des Machines Bull is incorporated in the Gamma 60. In effect what they have said is that, because data input and output units are so slow compared with the arithmetic units and other electronic circuits of a computer, it is desirable to link a large number

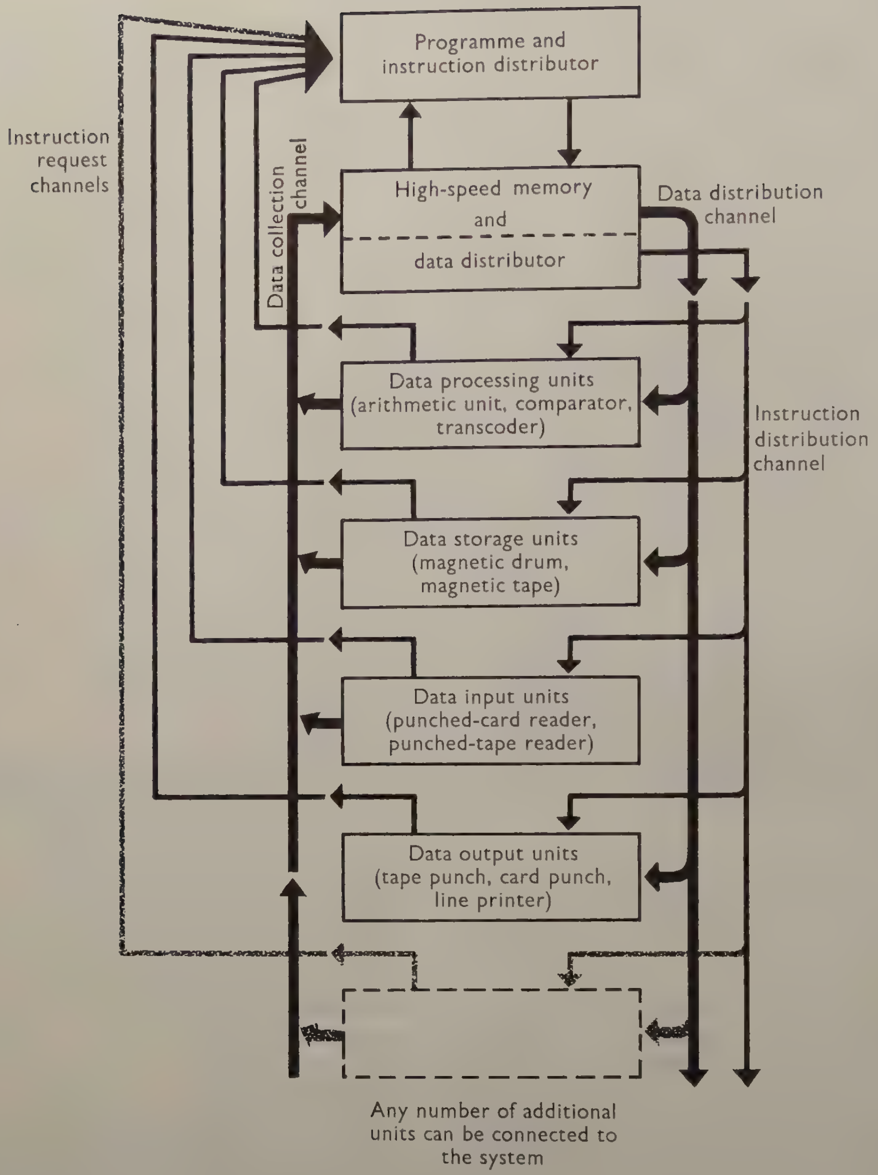

Programme and instruction distributor
Instruction request channels
Data collection channel
High-speed memory and data distributor
Data distribution channel
Data processing units (arithmetic unit, comparator, transcoder)
Instruction distribution channel
Data storage units (magnetic drum, magnetic tape)
Data input units (punched-card reader, punched-tape reader)
Data output units (tape punch, card punch, line printer)
Any number of additional units can be connected to the system

Diagram showing how the various operating units are connected to the central high-speed memory, the heart of the Gamma 60 *system*

of these slow units in a common system and operate them simultaneously in parallel. This also implies that the system must be capable of working on several programmes at the same time. This is because, generally speaking, a programme proceeds step by step and obviously it is impossible to perform several steps simultaneously if the results of one step have to be obtained before the next is begun.

Above is a diagram showing how the various units in a Gamma 60 system are interconnected. The centre of the system is the high-speed memory and data distributor to which is connected the programme and instruction distributor. The various operational units are connected in turn with this central assembly via a data collection channel, a data distribution channel and an instruction distribution channel. These channels are common to all units and any number of units can be linked to them. In addition, each unit is connected with the central assembly by its own instruction request channel and also by a separate data request channel.

There are four types of unit: data processing units, data storage units, data input units and data output units. As the name implies, data processing units perform such functions as calculation, comparison and data translation. In this last sequence, information read from punched cards or tape is converted into the machine code and at the same time it is rearranged and edited. Gamma 60 is provided with two types of data storage unit—magnetic drum and magnetic tape. Punched paper tape and punched-card readers are used for data input units, and output data are recorded by paper tape punches, card punches or line printers.

In the diagram only four units are shown; these indicate the four different types. In a diagram of a real system, there would, of course, be one block for each unit fitted and, even in the smallest installation, 15 or more units would be linked to the information channels.

As all these units are operated in parallel, obviously they cannot be continuously controlled from the central assembly. Each unit, therefore, is provided with sufficient instructions and data for it to be able to operate entirely on its own. It only communicates with the central assembly when it either requires further instructions or has completed the task set and wishes to transfer data. Thus each unit possesses a considerable degree of independence, or autonomy.

To illustrate how this works in practice, let us consider the operation of a punched-card reader. This unit may have just received an instruction from the programme distributor to read the next card—an instruction that will have arrived via the data distributor and the instruction distribution channel. From now on the reader operates on its own. It begins to read the card and stores the data within its own register. When the register is nearly full the reader sends a signal to the data distributor saying that it is ready to transmit the first quantity of data. The data distributor receives similar request signals from other units, but, because only one unit at a time can transmit data to the central high-speed memory along the data collection channel, the requests are placed in appropriate positions in a queue. When the request from the card reader reaches the head of the queue, a signal is sent to the card reader. The data are immediately transferred from the card reader register to the high-speed store and the reader continues reading the remainder of the original card and thus refills its register. When the card has been read and all the data transmitted, the reader sends a signal to the programme distributor requesting the next instruction.

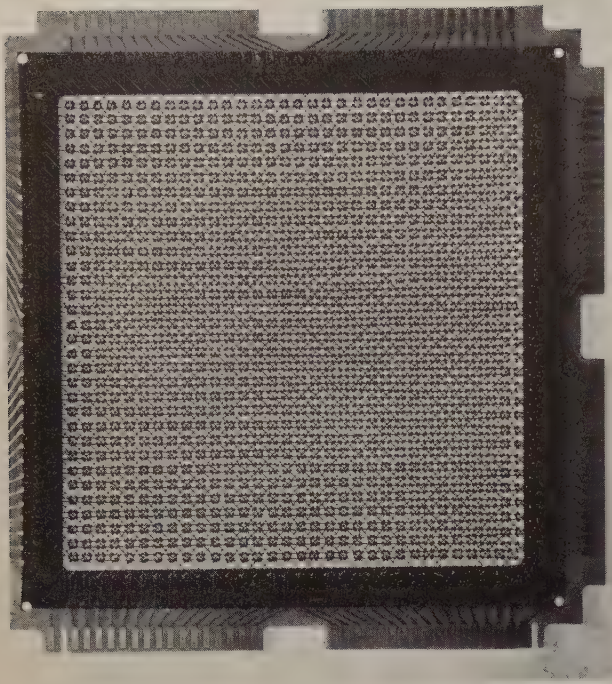
Set down in writing, this appears to be a rather long and tedious procedure. In fact, it is not—as an examination of typical operating times will show. Data are transferred between the separate units and the central assembly in quantities of a fixed size called a catena. A catena consists of 27 bits: 24 for data, the remaining three being check bits. Both the data distribution channel and collection channel can transfer 100,000 catenae a second. A punched-card reader operating at 300 cards a minute can only provide, at the maximum, 240 catenae a second; obviously, the transfer of data from the reader is not going to occupy much of the data transfer capacity.

By letting each unit work independently at its own speed and transferring data and instructions to and from it rapidly, as and when required, many units can be kept simultaneously fully employed. This, then, is the secret of Gamma 60.

Of all the catenae passing along the distribution channel, one in every three or four will be going to the arithmetic unit, because this is the fastest in the system; one in every ten to 30 will be on its way to an information storage unit, and only one in every 400 will be coming from a data input unit—these being the slowest units. These overall performance figures provide the basis for a system of priorities. Because the slowest units communicate with the central assembly infrequently they are given the highest priority to use the data distribution and collection channels.

As stated earlier, the number of programmes that can be run simultaneously is only limited by the number of input and output units fitted to the system. Obviously, one input and output unit must be available for each programme, otherwise it would be difficult to sort out the results. The programme distributor will ensure that the instructions for the separate programmes are despatched to the correct units and also that the requisite calculations are performed in the correct order.

With such a data processing system it is wrong to attempt to assess its suitability for a particular job merely on the basis of the performance of the input and output units. This, of course, is apt to be so with any data processing system, but is even more pertinent when systems like the Gamma 60 are con-



A panel of magnetic cores used in the high-speed memory

sidered. This complicates matters for those firms engaged on computer evaluation studies because the cost of performing a particular job will depend, to a large extent, upon the number and types of programme they think they will be running in parallel.

Before the general information already given about the individual Gamma 60 units is amplified by a brief description of each item of equipment, its purpose and performance, something must be said of the way information is coded.

Alphabetical letters, decimal figures and a number of special symbols are included in the machine code. Each character is represented by a 6-bit code group. As each catena has 24 bits, it can contain four characters. Where numbers alone are being handled, decimal figures can be represented by the standard 4-bit decimal binary code.* In this case, each catena contains six figures.

The high-speed memory, the heart of the system, is composed of magnetic cores. From one to eight magnetic-core storage blocks can be fitted, each having a capacity of 4,096 catenae (98,304 bits). Maximum capacity is therefore 32,768 catenae (786,432 bits).

The performance of the arithmetic unit when handling factors containing ten digits in floating decimal point notation is as follows:—

+ and −	100 microseconds (0·0001 second)
×	300 microseconds (0·0003 second)
÷	600 microseconds (0·0006 second)

Any two items of data can be compared by the comparator unit, or a single number can be compared with two others and its magnitude with respect to them indicated. Variable length entries can be compared up to a maximum length of 256 catenae (1,024 characters).

Transcoder unit

Data read from punched tape or punched cards are automatically edited and translated into the machine code by the transcoder unit. This unit also performs the reverse operation and edits and translates computer output data into the correct output code. Arithmetical operations on binary numbers and logical "decisions" are performed by the logical unit.

Information storage capacity is provided by magnetic drum and magnetic tape. The surface of the drum is divided into 128 tracks and 200 catenae can be recorded on each track; maximum capacity is therefore 25,600 catenae. Data, in bulk, are stored on magnetic tape half an inch wide. Eight tracks are recorded on the tape. One track is for synchronizing the tape with the computer system; the remaining seven are for data. The tape is traversed at 75 inches a second and a spool contains 2,400 feet of tape. Data are read from or recorded on magnetic tape at a rate of 3,750 catenae per second.

A combined punched-card reader and punch is one of the data input and output units. Standard 80-column punched cards are read at 300 a minute and also punched at 300 a minute. While data are being read from one card, results are punched simultaneously in another. Answers can be punched in the original card from which the factors of the calculation were obtained. Cards emerging from the unit are directed into one of three channels, consequently limited sorting is performed as a subsidiary operation. Another data input unit is a punched-card reader which reads 300 cards a minute. A punched paper tape reader is also built for reading either 5-channel or 8-channel punched tape at a speed of 300 characters, or rows, a second.

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*See "The universal language of computing," *Data Processing*, January-March, 1959.

Output data are recorded by a line printer at 300 lines a minute. Each line contains up to 120 characters and any one of 60 characters can be printed at each position. Or a 5-channel or 8-channel paper tape punch can record characters at 25 a second.

Information stored in any location within the machine can be requested and printed out by an electric typewriter that forms part of the control desk. This, of course, is also the position from which the operation of the machine is supervised.

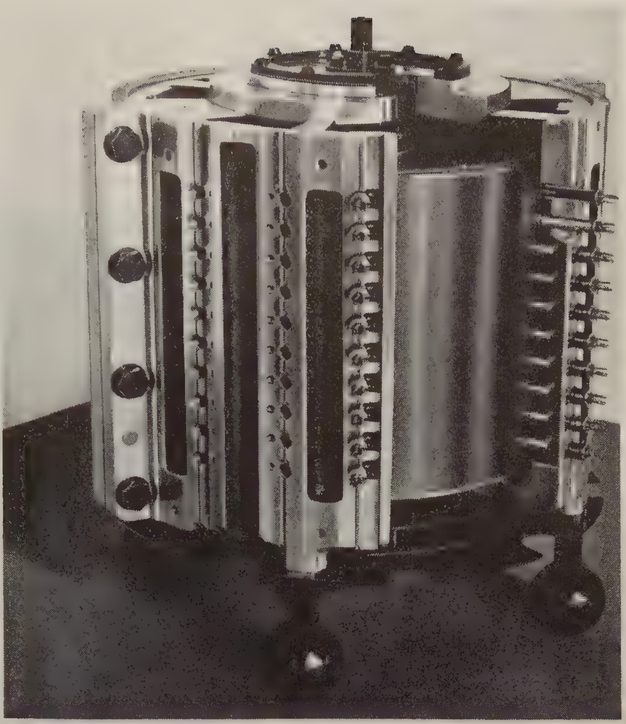
As stated, a Gamma 60 data processing system can contain any number and combination of the units described. Also, any of these units can be added to an existing installation to increase its capacity as conditions demand.

No mention has been made of data transcription units. This is because, with the Gamma 60 system, special transcription units are not necessary. Magnetic tape provides bulk information storage capacity and, if data are to be transferred from punched cards or punched tape on to magnetic tape, this transcription is performed simultaneously with other work. Thus the two objections to transcribing data on to magnetic tape, that either the computer is used inefficiently or an expensive transcription unit has to be used, do not apply.

When the programme is written for a data processing sequence the addresses where data are stored are quoted as "relative" addresses. That is, when the machine stores the programme it does so in the locations that are available at the time; the actual positions occupied by the data will not be known by or be the concern of the programmer. As long as he knows and quotes the "relative" addresses, the machine will always locate the correct item.

Parallel programming

In programming, advantage is obviously taken of the fact that the individual units in the Gamma 60 operate independently and thus enable several steps to be performed simultaneously. A simple instance might be that when a certain stage in a programme is reached, the arithmetic unit performs a calculation and, at the same time, two numbers are compared in the comparator. The results of these two separate operations are then combined and the programme continued. In this way the time of handling a programme on the Gamma 60 is shorter than on a computer where each step has to be performed separately in a strict sequence. A complete set of automatic programming codes for both scientific and commercial data processing problems is supplied with the machine. Included among these are subroutines designed to take full advantage of the parallel programming feature just described.



Magnetic drum information storage unit

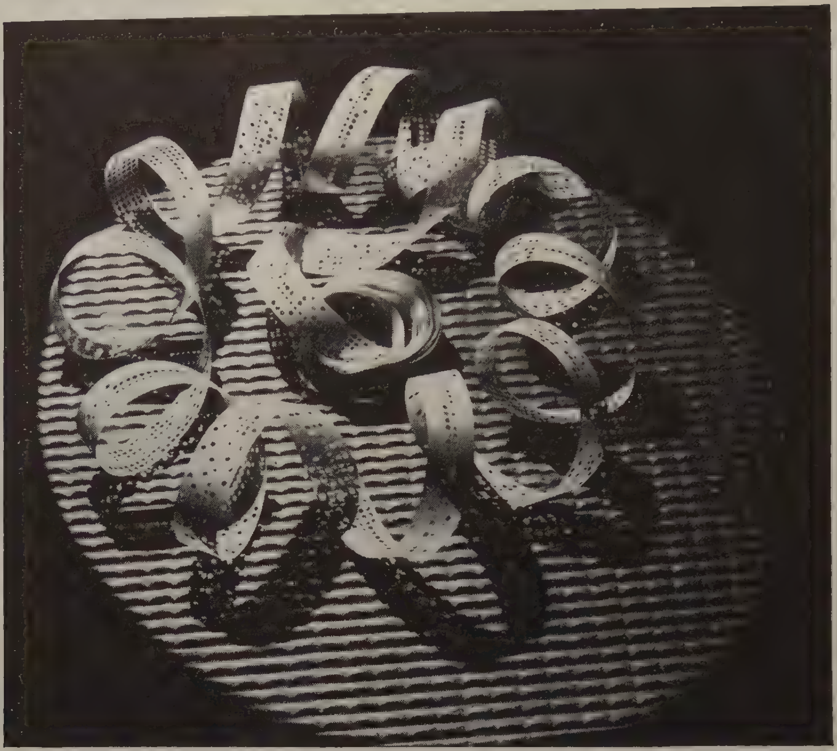
Over 35,000 transistors and diodes are used throughout the design. All circuit elements are mounted on removable plug-in chassis for ease of fault location and to permit servicing by replacement.

Gamma 60 represents a radical departure from "conventional" computer design. It possesses two great attractions for commercial users: the ability to perform simultaneously several unrelated programmes, and the system can be extended easily and to an unlimited size to suit the growing needs of the company that uses it. Also, because the data input and output units are relatively simple the cost of increasing the capacity of the system is not high.

To date, nine Gamma 60 installations have been sold, the majority to commercial firms; the purchasers are three insurance companies, two banks, a scientific research organization, the French Railways, the Belgian Telephone and Telegraph service and an industrial company.

Punched paper tape

What it is, how it is used, future developments



Punched paper tape has established itself as one of the three documents of data processing—the other two, of course, are magnetic tape and punched cards. Originally it was used solely for telecommunications; then as a means of feeding information into or recording the results produced by electronic digital computers; but within recent years the number of other applications in commerce and industry has increased considerably. Now, many varieties of automatic system are operated entirely by punched paper tape. The reasons why this is so are given in the following article in which the various characteristics of punched paper tape are discussed

The main attraction of punched paper tape as far as the user is concerned is undoubtedly the fact that it is cheap to buy (3s. 6d. per 1,000 feet) and the equipment needed to handle it is inexpensive in terms of the costs usually associated with data processing machinery. A ten-character-a-second printer operated by punched tape costs about £300 and an automatic punch for recording data at 30 characters a second costs £200. Faster printers capable of printing 100 characters a second and tape punches capable of punching 300 characters a second are available or are being developed. Naturally these machines cost more, but even so they are cheap compared with other forms of data processing equipment. It is probably true to say that nowadays data can be recorded and read back at almost any speed a user cares to specify—provided he is prepared to pay the price of the machine developed.

It would be unfair to suggest that price is the sole attraction. Paper tape is a robust medium on which to record data and it is simple both to use and to understand. Consequently, people are not deterred by the thought of having to employ it in their everyday work.

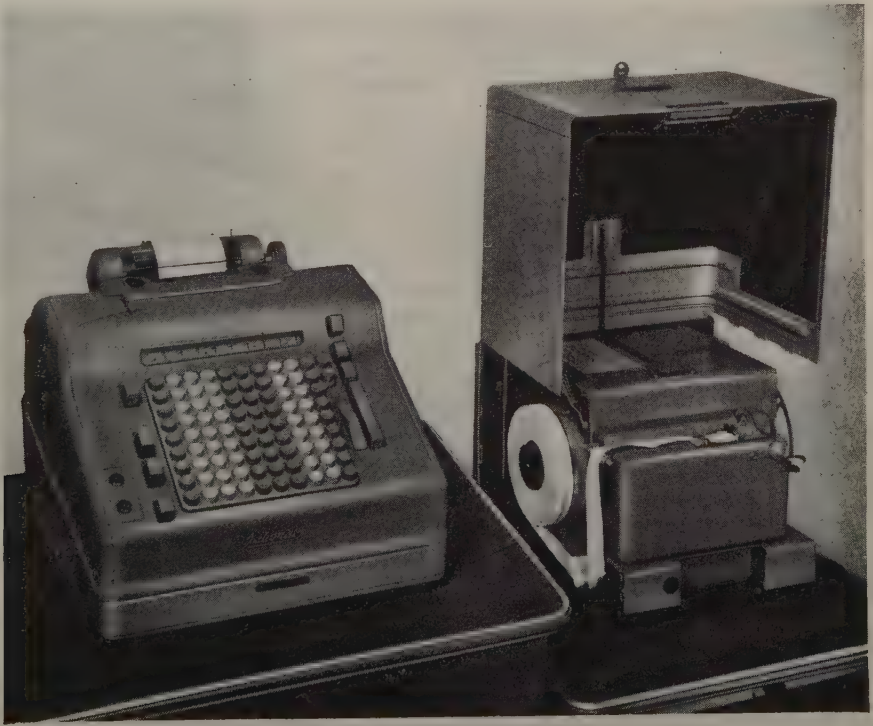
Also, paper tape punches are simple compact machines that can often be fitted to or operated in conjunction with standard business machines. In this way, data can be captured at source as a byproduct of another necessary operation. Examples are tape punches fitted to accounting machines*, electric typewriters†, cash registers,‡ adding machines, ticket-issuing machines and many other similar items of business equipment.

A further feature which commends paper tape to many people is the fact that it has been used in telecommunication work for over 30 years and the machinery that handles it is often virtually standard telecommunication equipment. As a result of these years of development, punched-tape units are reliable. Also, in this connection, paper tape offers the advantage that data recorded on it can be transmitted automatically over public or private Telex systems to almost any part of the world. At the moment this may not appear to be a significant advantage, but if large centralized data processing installations are created, as there is every likelihood that they will be, the ability to transmit data quickly from outlying sources will be important.

These then are some of the reasons why punched paper tape is proving so popular in the data processing world.

On the question of transmitting data by Telex lines: many companies, computer manufacturers especially, are already carrying out tests to determine the accuracy with which information can be transmitted in this way. Errors occur, but it has been observed that they usually happen in batches. Several techniques have been evolved to discover and locate these errors. A simple method, when numerical data are being sent, is to include a check sum at fixed intervals. This check sum is the combined total of all figures sent since the last check sum was transmitted. A register at the receiving end can be set to compile, automatically, the total of all the separate values received and this is compared with the check sum when it arrives. If the two figures agree, the transmission was accurate. If they disagree, that particular block of data is then retransmitted. Techniques such as this, as well as engineering improvements to the

A paper-tape punch connected to a National book-keeping machine



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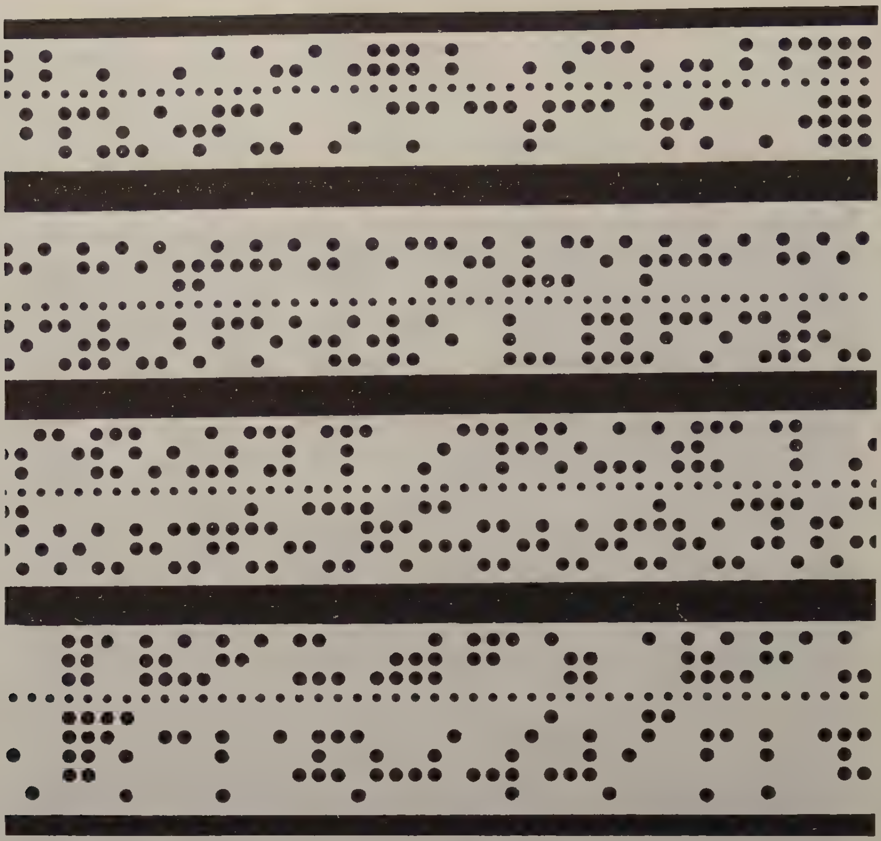
*See "Accounting machine plus paper tape punch," page 198, October—December, *Data Processing*, 1959.

†See "Accurate copy typing at 100 words a minute," page 222, October—December, *Data Processing*, 1959.

‡See "Recording data at the point of sale," this issue, page 2.



Examples of 5-, 6-, 7- *and* 8-*channel paper tape*

transmission lines, can make the sending of data by Telex a sound and efficient method of communication for data processing purposes.

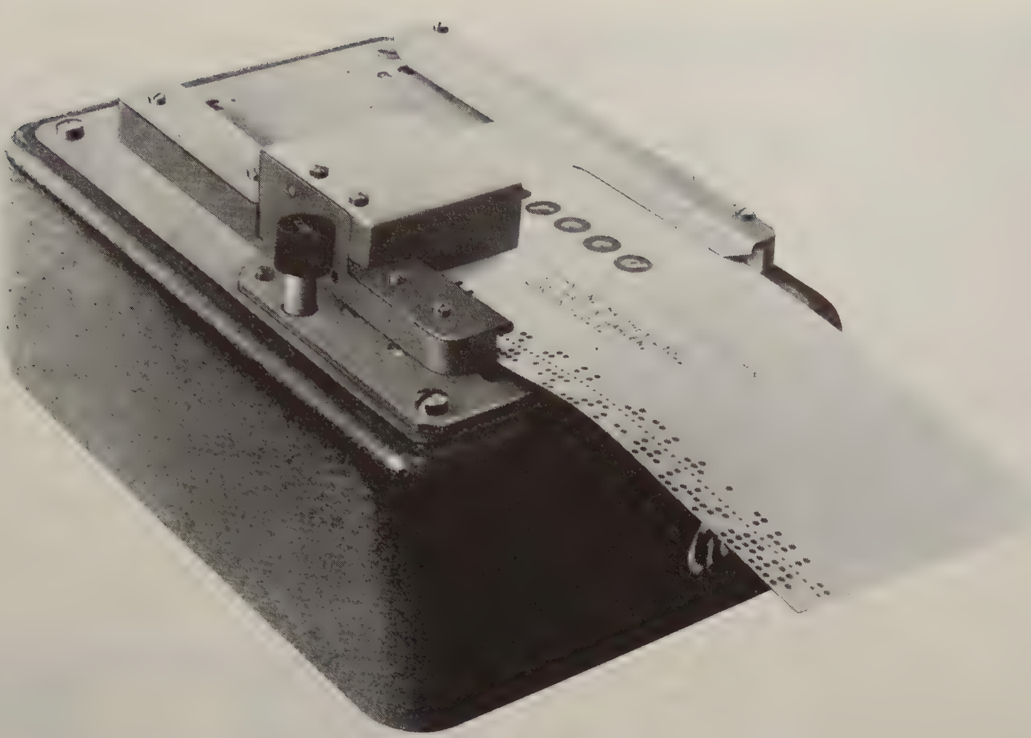
One of the few disadvantages of recording data on paper tape is that when additional information is inserted, or errors corrected, the tape has to be cut and a new piece spliced in. Although this is not difficult to do, it is a manual process and takes a few minutes to complete.

Tape obviously has to be tough to withstand constant handling and for this reason it is made from parchment. Over 2,800 characters can be recorded on one pennyworth of tape.

It has already been stated that punched tape was developed originally for telecommunication work. The tape used contains five channels. Subsequently, when punched tape was needed for commercial data processing 6-, 7- and 8-channel tapes were created. Examples of these tapes are shown in the illustration. (The continuous line of smaller holes down the length of each tape, near the middle, are sprocket holes in which toothed wheels engage to feed the tape through the various machines.)

Semi-perforated tape provides a continuous surface on which data can be printed as well as punched. Towards the left, the perforations are shown partly raised

Data are recorded in tape by punching holes in a row across the width. Each row represents one character and the pattern of the holes punched indicates the particular character. In the narrowest tape, since a hole can be punched in any of the five channels, the number of unique hole combinations possible is 2^5 or 32. Thus 32 characters can be represented by a 5-hole code. More than 32 separate items can be identified if each code group is made to represent two or



An edge-punched card passing through a reader. Data are recorded along the edge of the card in the same punched-hole code used for paper tape

A Model 54 teleprinter equipped with a paper-tape reperforating attachment

more characters and a special signal precedes the punched data to indicate which interpretation is to be used. In certain circumstances this can be cumbersome—hence the development of tapes with more information channels so that larger numbers of characters can be identified uniquely. Every additional channel doubles the number of different hole-code groups available. Thus in a 6-channel tape, 64 different characters can be recorded, in a 7-channel tape, 128, and, lastly, in an 8-channel tape, 256. The code associated with the last tape should be able to cope with all the letters, figures, special symbols and instructions that are likely to be needed for commercial data processing work.

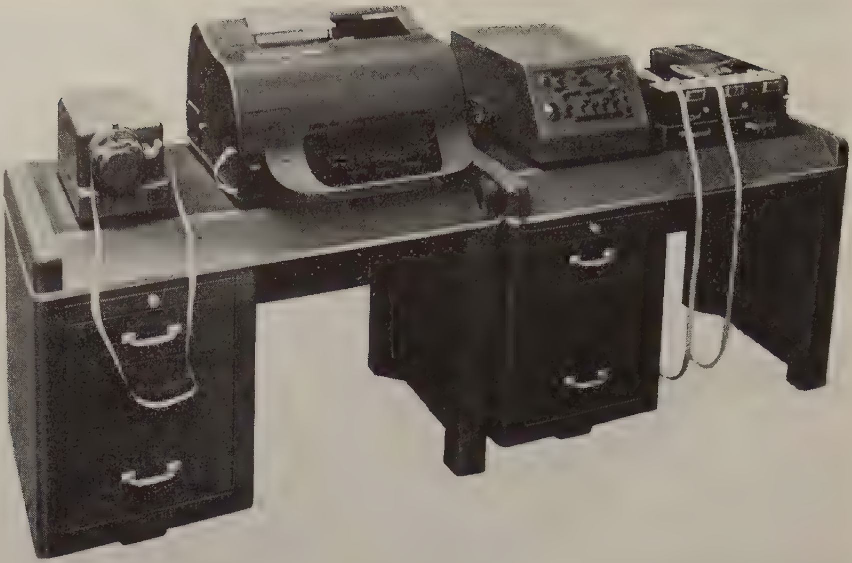
Edge-punched cards

A variation on the punched paper tape theme is provided by edge-punched cards. Holes are punched down the side of these cards in much the same way as they are punched in paper tape. Information is then printed on the plain portion of the card to identify the data recorded. These cards are fed through reading units as is the case with punched paper tape.

Permanent data that will be required repeatedly are usually recorded on edge-punched cards which are then retained in a file ready for instant use. Such data are customers' names and addresses, stock reference numbers, stock prices, staff numbers, names, etc.

Perfect Tape Comparator assembly plus teleprinter

(Below) Model Seventy-five teleprinter with paper-tape reperforating attachment. On the extreme left of the desk is a punched tape reader



Data are punched in paper tape either manually or automatically. Keyboard perforators are used for the manual preparation of tapes. Two types of machine are available, both fitted with keyboards similar to that of a typewriter. One perforator produces punched paper tape only, while the other machine—a conventional teleprinter—prints a normal document as well as producing a punched tape. The printed document is very useful as it provides a permanent record of the data entered on the tape and therefore can be used to check the accuracy with which the original data was transcribed.

Naturally, the speed of punching varies according to the complexity of the data transcribed and the actual tape perforator used. During the course of a day, an operator using a Creed Model 7P/N perforator can punch an average of 10,000 characters an hour. Higher speeds are possible, the operational limit of the

An operator using a keyboard perforator can punch 10,000 *characters an hour*

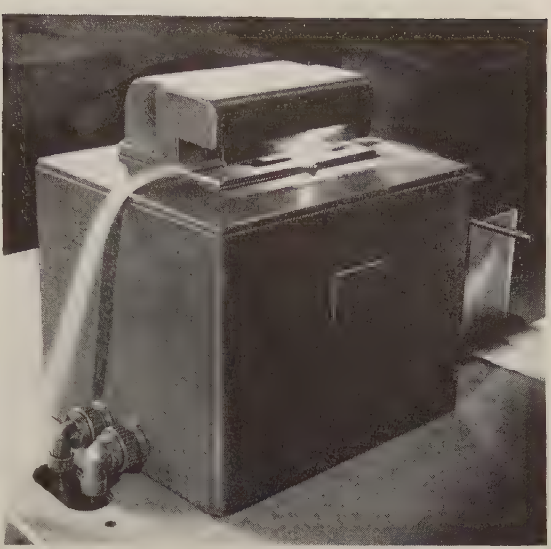
7P/N machine being 14 characters a second. The limit of the Creed Model 54 teleprinter perforator (this is one of the machines that produce a typed document in addition to the tape) is lower—seven characters a second, although this is still well above the speed an operator can maintain consistently.

Obviously when transcribing data it is most important to ensure accuracy. Undiscovered errors in data supplied to an electronic computer can prove very expensive. Computers cost £50 or more an hour to run, and if an entire calculation has to be repeated because of errors in the original input data, costs soar. As it has been estimated that an operator makes one mistake in every 300 to 2,000 characters transcribed, it can be appreciated that verification is very necessary.

Two items of equipment have been developed for this work. One is the Creed Model 90 tape verifier and the other is called the Perfect Tape Comparator. Both automatically compare the transcriptions of the same data produced by two different operators.

The Model 90 verifier consists of three units: a keyboard, a tape reader and an automatic reperforating punch. This equipment is used as follows. A punched tape prepared by the first operator is placed in the tape reader and a second operator, working from the original documents, enters the same data in the same sequence on the verifier keyboard. If the data entered on the keyboard agree with the data read from the tape, this confirms that the transcription is correct and the data are punched automatically by the reperforator into a second tape called the verified tape. Should the data entered on the keyboard disagree with those punched in the tape, the keyboard is locked. The operator then determines which entry is correct and ensures that only these data are punched into the verified tape.

When the machine called the Perfect Tape Comparator is employed, the checking procedure is somewhat different. Data are first transcribed from the original documents into two separate tapes by two operators. These tapes are then compared automatically in the machine. The latter consists of two tape readers and a tape reperforator. Each tape passes through a reader and the entries recorded on the tapes are compared, character by character. If identical, these data are punched automatically into a third tape—the verified tape—by the reperforator. If the recordings disagree, the machine stops and an operator has to examine the two input tapes, identify the error and see that the correct data are punched into the verified tape. The machine is then restarted and the automatic comparison procedure continues.



Reading input data from punched paper tape; a photoelectric reader, connected to a Ferranti Pegasus computer, shown in operation

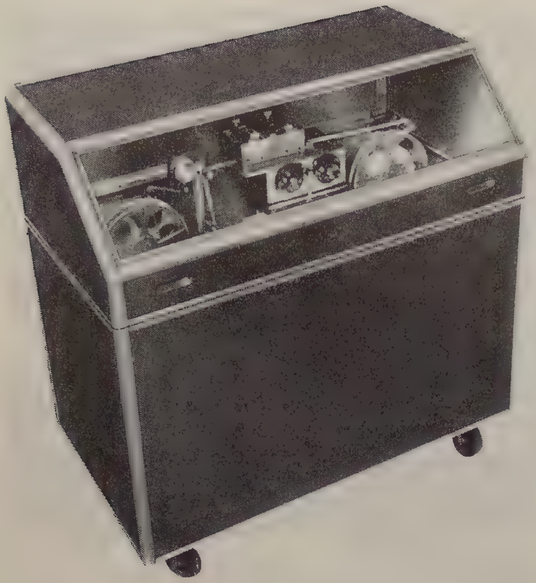
Tapes are checked by this equipment at the rate of five characters a second. A teleprinter can also be connected to the system so that a record of the data on the verified tape is printed at the same time.

A simpler comparator is also available which compares two supposedly identical tapes at a speed of 26 characters per second.

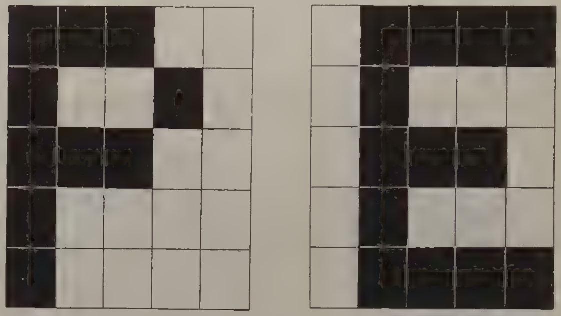
So much for recording and verifying data in tape. To perform the reverse transcription and produce printed copies of data punched in tape is work for which standard telecommunication teleprinters are frequently employed. The normal teleprinter prints seven characters a second. Recently, an entirely new design of teleprinter, the Model Seventy-five, was introduced by Creed. This machine can print ten characters a second. It is smaller and lighter than the standard machine and, though its performance is better, it costs the same—£300.

With the exception of the verifiers, the punched-tape machines described are basically telecommunication units. At present, by far the biggest demand for punched-tape equipment for data processing has arisen from the need to provide electronic digital computers with a means for reading and recording data automatically. As a result, several computer manufacturers have developed their own photo-electric readers that can scan tape at speeds from 200 to 1,000 rows (characters) a second.

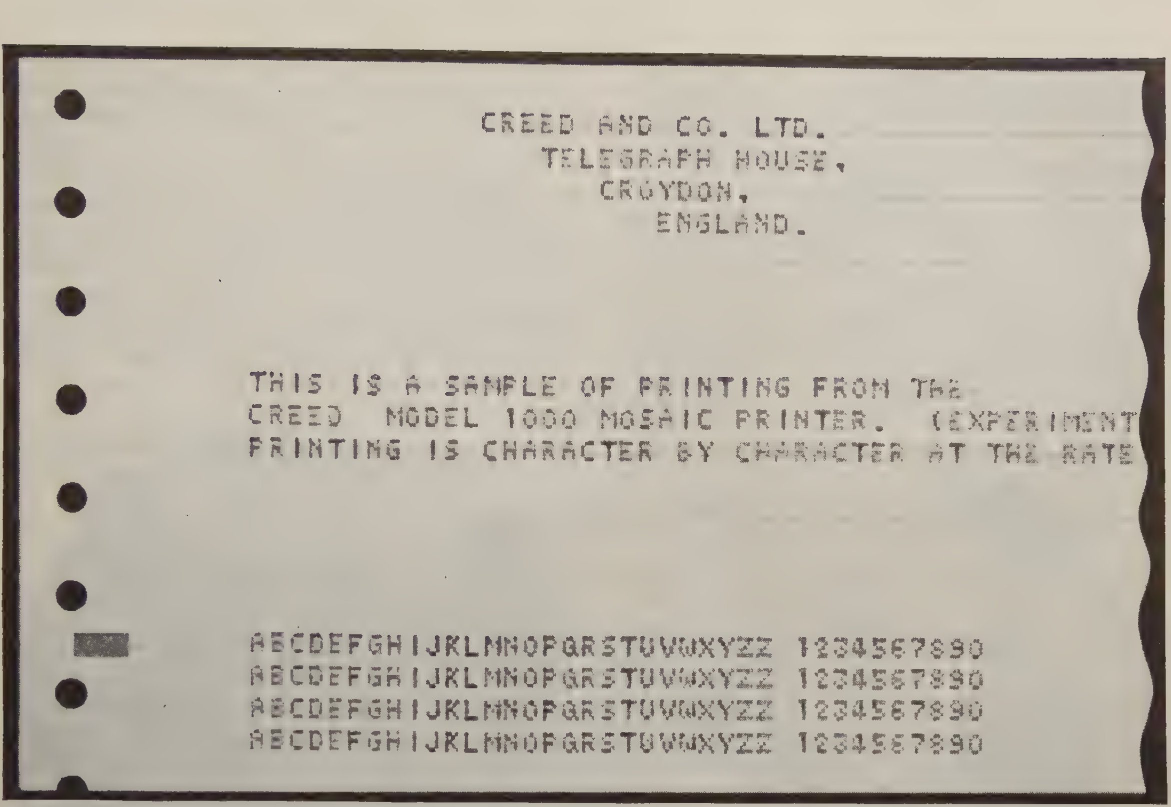
To record computer output data, it has been the practice to employ electro-mechanical tape punches which operate at speeds of up to 30 characters a second. A printed record of the output data is obtained by feeding the tape directly from the punch to a reader, which is connected, in turn, to a conventional teleprinter. Generally, the output punch is not working continuously and so the teleprinter, operating at the slower speed of seven or ten characters a second, ultimately catches up with



(*Above*) *The Creed Model* 3000 *tape punch records* 300 *characters a second*



(*Below*) *Output data from this Ferranti Pegasus* 2 *computer are recorded by a Creed* 300-*character-a-second punch. On the right are three teleprinters used to prepare printed documents from the data punched in the output tape*



CREED AND CO. LTD.
TELEGRAPH HOUSE,
CROYDON,
ENGLAND.

THIS IS A SAMPLE OF PRINTING FROM THE
CREED MODEL 1000 MOSAIC PRINTER. (EXPERIMENT
PRINTING IS CHARACTER BY CHARACTER AT THE RATE

ABCDEFGHIJKLMNOPQRSTUVWXYZZ 1234567890
ABCDEFGHIJKLMNOPQRSTUVWXYZZ 1234567890
ABCDEFGHIJKLMNOPQRSTUVWXYZZ 1234567890
ABCDEFGHIJKLMNOPQRSTUVWXYZZ 1234567890

(Left) Greatly enlarged outlines of the letters P and E produced by the high-speed mosaic printer. (Above) Part of a document printed by the experimental mosaic printer—this document is shown full size

the punch. However, in commercial work where large quantities of data have to be handled, it is desirable to have punches and printers with a better performance in order not to restrict the operation of the computer.

To meet this demand for higher recording speeds, just over a year ago Creed introduced the Model 3000 tape punch. This can record 300 characters a second and is the fastest punch manufactured in the world to-day. It is thought that 300 characters a second represents the highest speed a mechanically operated punch can attain. Three models are built. One punches 5-channel tape, the second 6- or 7-channel tape and the third 8-channel tape.

Where the punch is connected directly to a computer, the tape can be divided into a number of separate lengths and fed to a battery of teleprinters, and thus speed up the process of converting output data into print. An installation of this kind, working in conjunction with a Ferranti Pegasus 2 data processing system, is shown in the accompanying illustration.

The type 3000 punch costs from £2,500 to £2,850, depending on the model, and an automatic tape reader teleprinter transcription unit costs about £400. Therefore, a data output recording and printing installation similar to that shown with the Pegasus 2 costs about £4,000.

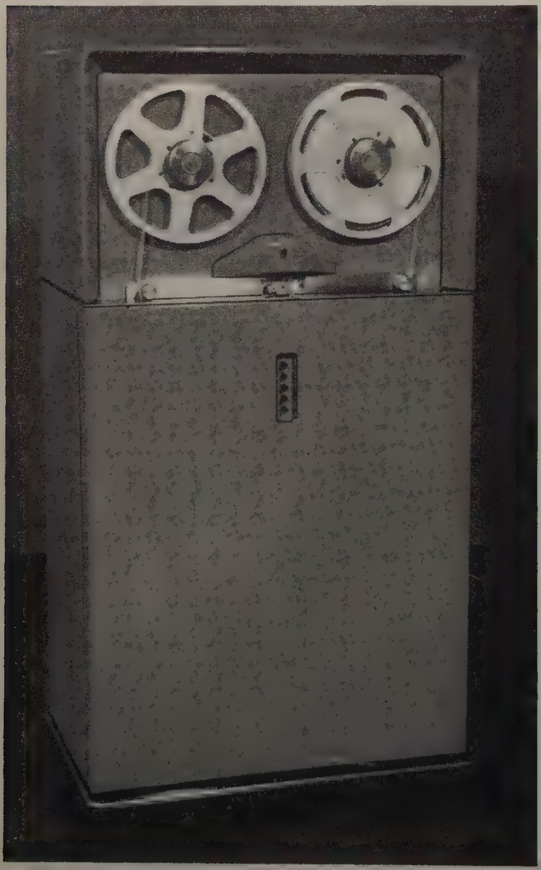
For work where fast printing is needed, Creed are now developing a high-speed serial printer which prints 100 characters a second. This machine is still very much an experimental model and a considerable amount of development work has to be done before the design is released for production.

To record characters sequentially at this speed an entirely new method of printing had to be devised. The printing head consists of 25 styli arranged in the form of a rectangle containing five rows of five styli each. Each stylus is rectangular in cross-section and a character is formed by impinging the styli on the paper to produce a pattern of rectangular dots that closely resemble the true outline of the character. Examples are shown of the patterns created for the letters P and E. A facsimile of a printed document produced on this machine is also illustrated. It can be seen that a perfectly legible record is produced.

The styli are operated by hydraulic impulses and the valves that release fluid to the styli are opened and closed by electric signals received from the computer. Of course, the printer can also be operated independently of the computer (off-line) in conjunction with other types of data transcription unit, such as, punched-card and punched-tape readers or magnetic tape decks of various types.

In addition to the production of high-speed punches and printers, there are other developments aimed at making punched tape even more acceptable as a commercial document. One of these is intended to provide quick access to information stored on punched tape. A machine has been built with two storage reels on which over 1,000 feet of tape are wound. When information is requested the tape is run, at high speed, off one reel past a reading head until the approximate position of the required block of data is located. When this is found, the rapid-feed action is stopped and the tape is then fed step-by-step until the data are located exactly. Finally, the information is read from the tape at a speed of approximately ten characters a second.

A high-speed—1,000 *characters a second—punched paper-tape reader for digital computers*



Over 120,000 characters can be recorded on one reel of tape and the average access time is 18 seconds. A 7-channel tape is used. Data are recorded in five of the channels, the sixth channel is reserved for addresses identifying specific blocks of data, and the seventh for machine control purposes. The capacity of the information store can be expanded, to an unlimited extent, by the addition of extra units. Access time remains the same at 18 seconds.

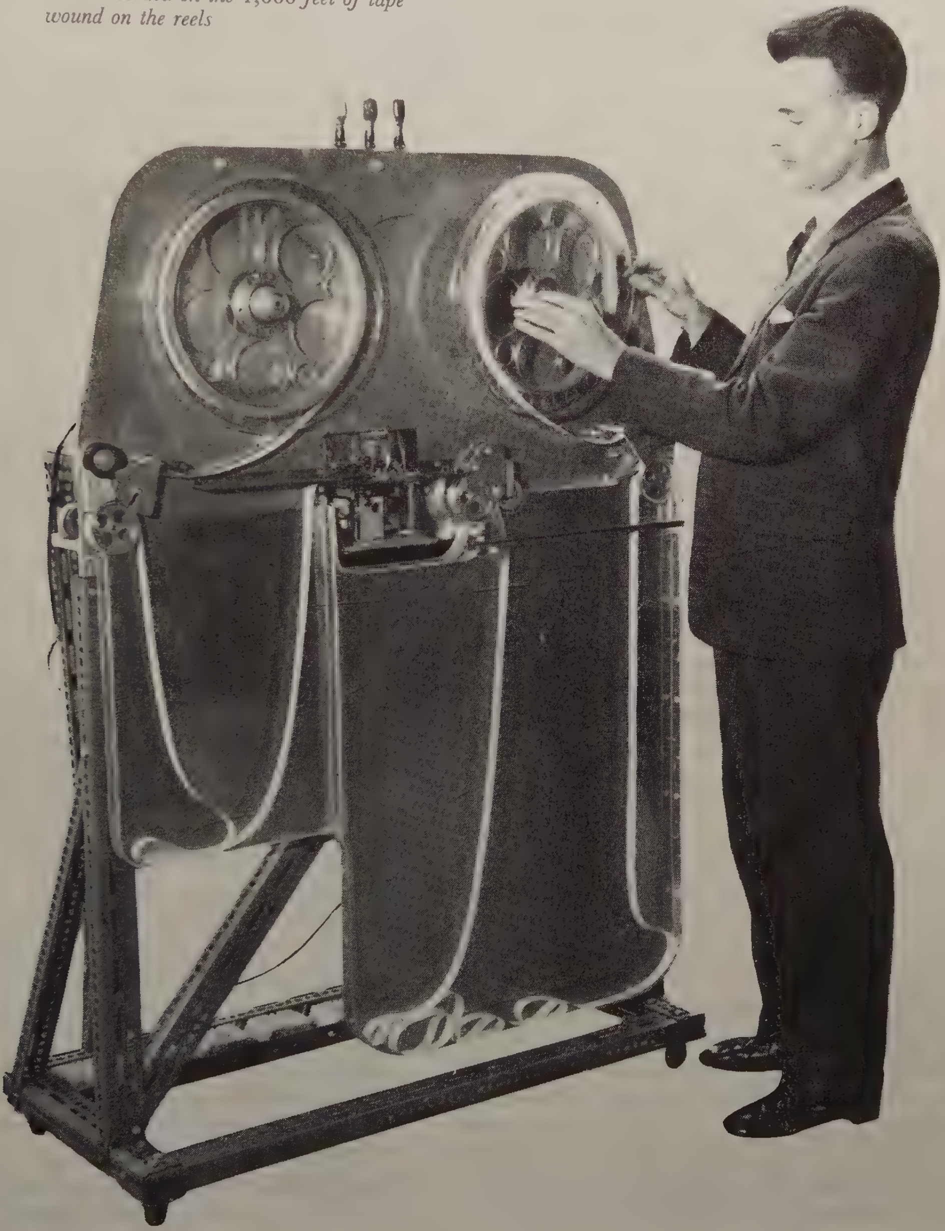
Experimental version of the Creed Model 1000 *high-speed mosaic printer*

Before 1945, all the punched-tape equipment produced was for telecommunication installations—both public and private. Telecommunications still provides the largest market for punched tape. Now, data processing applications are rapidly assuming greater importance. When computers were first developed, punched-tape equipment was chosen for input and output units primarily because the equipment was already available and was reliable and inexpensive. Nevertheless, at that time, both the computer manufacturers and the telecommunication firms were convinced that this was only a passing phase; it was recognized that the data handling speeds were not high and other means of recording data would be developed. Since 1945, however, the performance of punched-tape equipment has been greatly improved. Punching speeds have increased by a factor of over 40 and printing speeds by 15. Also, paper tape has proved to be a very simple, compact and versatile medium on which to record data, especially when used in conjunction with other types of business machines. As a result, nowadays, many new data processing systems are being developed that use punched paper tape as the prime means of communication between the various units.

Industry, in its turn, is also making extensive use of punched paper tape. Information recorded on tape can now control the operation of a production process or a machine-tool.

Punched tape that was introduced so casually and, so it was thought, transitorily, has to-day, become one of the accepted and established documents of the data processing world.

Punched paper-tape information store. Approximately 120,000 *characters can be recorded on the* 1,000 *feet of tape wound on the reels*



Controlling continuous processes by computer

Methods are being developed whereby the control of continuous-process plants can be handed over to electronic digital computers. This is desirable for several reasons, not least because, as processes become more complex, it is increasingly difficult for men to control and co-ordinate all the many factors involved—their reactions are too slow. And, errors, if not dangerous, can prove costly. Also, a computer can maintain consistent control over a process, thereby allowing more accurate information to be obtained of the operation of the plant and enabling the achievement of the most economical methods of working

Now that the electronic digital computer has been successfully developed into a machine of great reliability it is being widely considered for the control of continuous processes. There are at least four reasons for this: the increasing complexity of operating modern continuous-process plants, safety requirements, the need to repeat production conditions exactly and, in many processes, achieve the highest possible speed.

In general, the fact that methods of continuous production are constantly being improved and developed means that the equipment to be controlled increases in size and complexity. Although all the information about a process can be gathered together and presented to the man in charge, the quantity of data may eventually become so large that he is unable to cope with it and, sooner or later, some automatic equipment, such as a process-control computer, must be provided to digest the information for him and only draw his attention to unusual happenings.

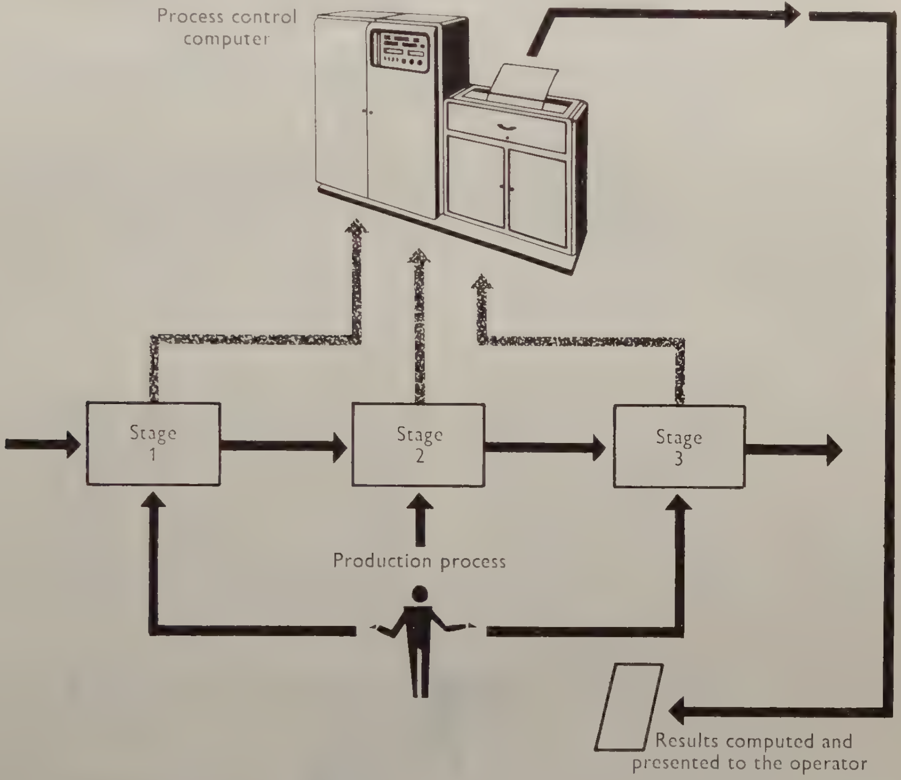
Also human operators make mistakes: in all probability many mistakes are made each day, but, being of a minor nature, they only have a small effect on the plant or the product. In spite of the provision of alarms and the design of "foolproof" circuits, eventually a more serious error may occur resulting in extensive damage to a costly plant. A computer, slavishly following the instructions of a programme, cannot make mistakes of this sort. Of course, the computer can break down, but, even in these circumstances, action can be taken automatically which will protect the plant from damage, even if the product being processed is spoilt.

Another advantage a computer possesses is that it does not become weary, bored or mesmerized. Few human operators respond quickly to signs of danger after a long period of passively watching instruments recording the progress of a production operation. With some critical chemical processes, the change from stable to unstable conditions occurs very rapidly—may occur before the operator is aware that anything is amiss. A computer can be programmed to take appropriate action in circumstances where this would be virtually impossible for a human operator.

Another reason why digital computers are being actively considered for controlling continuous-process plants is that operations can be repeated exactly. Even to-day, many of the conditions that govern the manufacture of a product, especially of chemicals, are imperfectly understood. Under manual control it is difficult, if not impossible, to distinguish what variations in output are due to alterations in the conditions of the actual process and what are due to subtle variations in the control techniques used by different operators. It is an established fact that one operator can consistently run a plant more efficiently than another, although there is no obvious discernible difference in their techniques. In contrast, a plant under the control of a computer is operated in an identical manner each time and thus true comparative operational figures can be obtained. This can lead to a better knowledge of the process. Thus it is possible to vary the working of the plant until the most efficient production technique has been discovered and the operating conditions established.

These are the main advantages to be gained from using a computer. But, because automatic process plants do not usually employ many people, the introduction of a computer will not normally enable large reductions in staff to be made since a certain minimum number must be present to operate the equipment and exercise general supervision.

Computers can be employed on continuous process work in three ways. The simplest application is data logging. In this case the computer does not run the plant. The process remains under the direct control of a human operator. What occurs is that readings from the various instruments, such as pressures, temperatures and settings of valves, are taken at specified intervals and are transmitted to the computer. Here they are converted into digital form and figures that indicate the state of the process are calculated from these data and typed out for the benefit of the operator. Thus the work of evaluating the performance of the plant is done automatically by the computer, and the results are presented to the operator for his assessment and also for his decision.

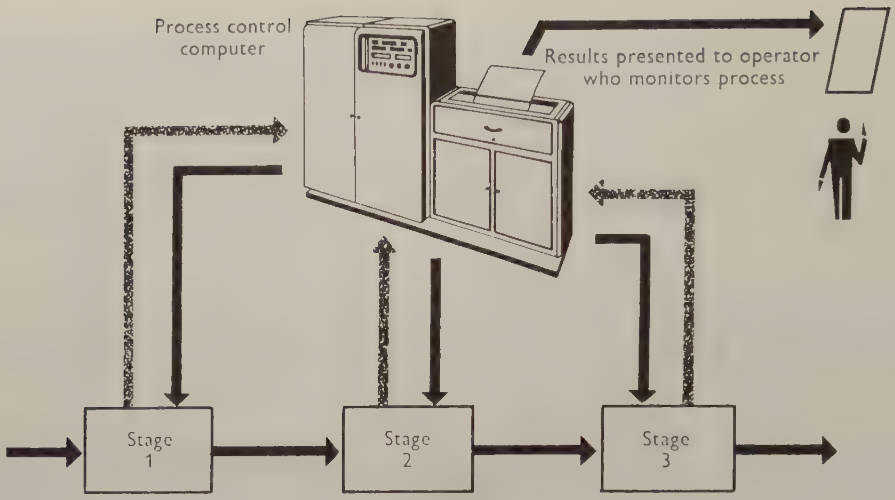


A computer being used for data logging. The production process is under manual control

In the second and more complex application a computer is used to supervise the many separate production stages of a manufacturing process. In a continuous production process, manufacturing operations are performed in a strict sequence upon the product as it passes through. Material is received from the previous stage and passed on to the next, but any variations in the manufacturing conditions made in the current stage only indirectly affect the operation of previous or following stages. Each stage possesses its own instrumentation, valves and other control equipment.

A computer can be linked to such a system to receive data from each stage. These data are assessed and the appropriate signals are sent back to the valves and other equipment of each stage to control the quality of the product produced. As a byproduct of this operation, readings are printed out for the benefit of the person who is monitoring the process, but, unless there is an emergency, he does not exercise any direct control over the manufacturing cycle.

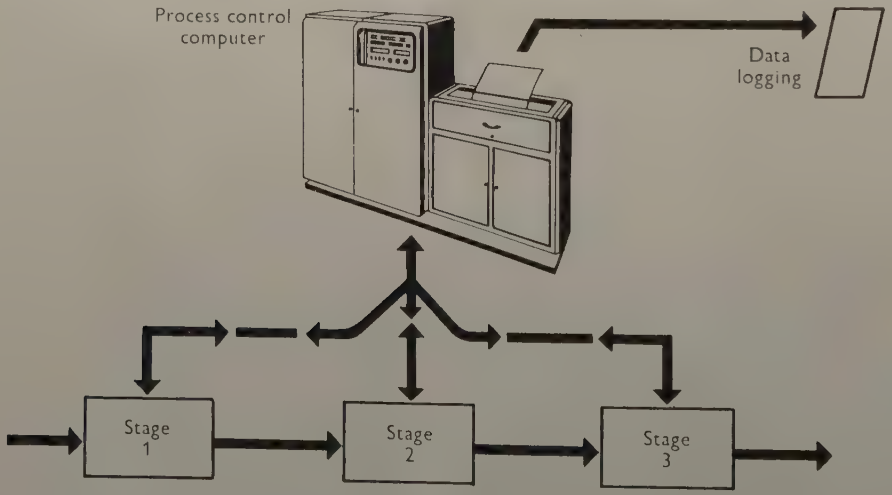
The third, the most sophisticated application is where the computer exercises direct control



A computer controlling a manufacturing process as a sequence of separate and unrelated stages

over the entire process, not as a series of separate, though interconnected, production stages, but as one continuous process. In this case the computer replaces all the separate control circuits needed for the individual stages. Increased flexibility of operation is obtained with this method because all the information is fed back to the computer and all control signals emanate from it. Readings taken at one point in the production cycle are used to modify the control signal sent to another part. If the method of control is to be altered, this can be achieved quite simply by altering the computer programme. It thus facilitates experiments designed to increase the efficiency of the plant. Otherwise, where the process is divided into a number of separately controlled stages, alterations in the mode of operation of the plant can involve quite a considerable amount of engineering work in changing instrumentation and fitting new control circuits.

Although an electronic digital computer can be applied in these three ways, much work has still to be done before an installation of the third, most advanced, type is achieved. There are several installations throughout the world where digital computers are used for data logging while the plant remains under manual control, and there are at least two installations where a computer is used for the direct control of a plant



A computer controlling a process as a single entity. Data received from one stage are used to modify the control signals sent to other stages arranged as a series of separate production stages. The technique of continuous process control by computer is still very much in its infancy.

One, if not the most important, feature a process-control computer must possess is, of course, extreme reliability. Because of this and the nature of the tasks, a special variety of electronic digital computer has been developed. One of the earliest to be announced in Great Britain was the Ferranti Argus. A brief specification of this machine is given in the accompanying table.

Reliability

As reliability and robustness are of such extreme importance, printed circuits and transistors are used throughout. An early prototype computer was operated continuously for eight hours a day for 18 months (about 3,000 hours). During this time no maintenance work was performed and only one transistor failed.

In November 1958 the first pre-production Argus computer was exhibited and shortly afterwards, in December, it was also subjected to extended life tests. The machine was operated continuously day and night for three months (over 2,000 hours continuous running). During this time no maintenance work was performed and no failure occurred.

For the control of a process, data about the operations have, of course, to be supplied to the computer. In the case of Argus it is proposed, where practicable, to use existing standard electrical instrumentation to measure the various factors governing the process. These signals will then be fed to the computer, where a special unit will convert the analogue signals into the required forms of digital signal. One of the major problems associated with the application of computers to process control work is to write a programme that will allow the computer to continue to control the process adequately in the event of an instrument failing or of incorrect data being transmitted back from one point because of some error. An operator can often assess whether the data he is presented with are correct or false, and can ignore the readings thought to be wrong. To provide this facility in a computer programme is a difficult task.

The problem can be overcome to some extent by fitting duplicate instrumentation at critical points. Or, if the true readings can be obtained by another method, this information can be fed in as a dummy input.

FERRANTI ARGUS COMPUTER

This machine is designed for continuous process control work. It is equipped with two types of information store, from both of which data can be obtained instantaneously. The computing store is made up of ferrite cores and has a capacity of 1,024 words. The programme and numerical constants required in the calculations are recorded in a peg-board store that can contain 1,024 instructions. It is possible to increase the capacity of this store to 4,096 programme instructions. Each instruction contains 24 bits; consequently, two 12-bit constants can be stored in the space normally occupied by one instruction.

Process control data are printed out on an electric typewriter fitted with a 20-inch carriage. Data received from electric instruments are converted into digital form by a subsidiary unit connected to the computer. Output control signals may be in either digital or analogue form. Transistors and printed circuit plug-in units are used extensively in the construction; there are no thermionic valves. The programming code is similar to that used for Pegasus. A special programme-interrupt facility is provided so that further short programmes can be performed repeatedly at fixed intervals.

ARGUS COMPUTER CHARACTERISTICS

Number system: binary
Mode of operation of arithmetic unit: serial parallel (two bits in parallel)
Times for arithmetical operations:
+ 20 microseconds (0·00002 second)
× 90 microseconds (0·00009 second)
÷ 180 microseconds (0·00018 second)
Type of instruction: plugboard
Word length: 12 bits (programme instruction 24 bits)

Immediate access store: magnetic cores of 1,024 words capacity
Plugboard store: 1,024 to 4,096 programme instructions
Data input: several hundred electrical analogue or digital signals
Data output: digital or analogue control signals, also data logged on typewriters, multi-point plotters, decimal displays, etc.

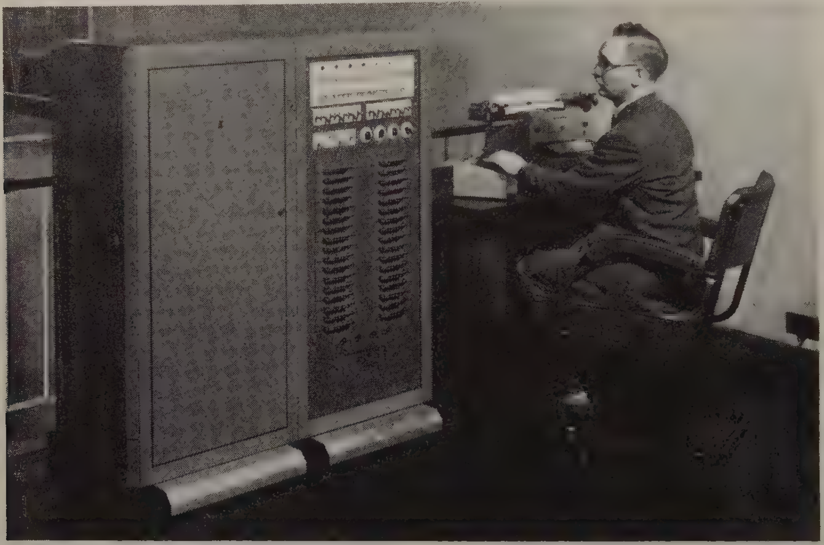
Another practical problem of great importance is what happens should the computer fail. Although the possibility of this can be made extremely unlikely, some safety procedure is obviously essential. Normally it can be arranged that, should the control signals from the computer be cut off, all the controls are held at their last settings. Where this "freezing" of the controls might create unstable conditions, the arrangement, naturally, is that if a signal fails to arrive the controls are automatically moved to a predetermined safe setting. For example, a venting valve may be arranged to open so that, in the event of a failure, the pressure in that part of the plant is automatically released.

A technical study of the application of an Argus computer to control the starting up of a high-pressure coal-fired boiler system of an electric generating station is being conducted jointly by Ferranti and Babcock and Wilcox. This apparently mundane problem is not as simple as it would appear. In all, over 100 factors have to be measured, including temperatures, pressures, positions of dampers and other controls, and about 40 output control signals have to be generated. In addition, at specified intervals, the values of certain factors need to be printed out for record purposes.

The computer is intended to control not only the operation of the boiler, but also the ancillary mechanical equipment such as the coal pulverizing mills preparing the fuel for the boiler and the pump supplying the oil used to ignite the boiler during the initial starting phase.

As the starting-up procedure is performed, a large number of checks have to be made to confirm that the boiler is functioning correctly before the next part of the sequence is initiated. To perform checks of this character a special interrupt facility is provided in the computer programme.

The computer is equipped with a timing register and, at set intervals, the main programme that the computer is obeying is interrupted so that a subsidiary or secondary programme can be performed. In the case mentioned, all the critical values that have to be checked from time to time to confirm the correct and safe operation of the plant are included in this secondary programme. When the checks have been completed, the computer returns to the original programme at the point where it was interrupted.



The pre-production Ferranti Argus process-control computer

Because the Argus is a fast computer, it is feasible to interrupt the programme every millisecond (0·001 second) or so. It is expected that in the boiler application described, about ten per cent of the total computing time will be spent on secondary programmes introduced by the interrupt procedure.

Argus is provided with two types of information store. One is a ferrite core store that has a

First production model of the Ferranti Argus computer. A second cabinet houses the data conversion circuits

capacity of 1,024 computer words. Each computer word contains 12 bits. Generally, numbers calculated within the computer will be retained in this store. The other store consists of a set of up to 64 plugboards in which the programme instructions are held, together with any numerical constants needed. These values are specified by placing ferrite pegs in the appropriate positions in rows of holes. The programme storage capacity is 1,024 instructions of 24 bits each. Alternatively, each location can contain two 12-bit constants. The programme store can be expanded to contain 4,096 instructions. Immediate access can be obtained to data recorded in both information stores.

Except for alterations in the capacity of the information stores, the basic Argus computer will remain the same whatever task it is used for. The electronic circuits that handle and convert the input and output data will be designed to suit the needs of the particular installation.

As the computer is fully transistorized, it is small in size and its power requirements, at 1,200 watts, are modest. It is contained within a cabinet 5 feet high, 6 feet wide, and 2 feet deep. Next to this is another cabinet which contains the electronic circuits needed for converting the input and output data. The first production Argus is expected to be ready early in 1960 and is shown in the accompanying illustration.

Although Argus is capable of being used in any of the three basic ways described earlier in the article, the first applications are likely to be to control plants operating as a sequence of separate production stages and to log data to provide a historical record of plant performance for subsequent analysis.

The application of process-control computers to modern industrial work will mean that more complex operations can be administered, that safety is higher and production sequences can be repeated with greater accuracy.

Two scientific-management

By Dr. P. Galambos, M.A.

In recent years, two operational research techniques have attracted great interest among management in both business and industry. One is called the Monte Carlo method and the other—a special case of mathematical programming—linear programming. Both these methods provide an aid for decision-making by management and involve a large amount of arithmetical work and data simulation. Consequently, the employment of electronic digital computers is often indispensable.

This article is concerned only with the uses of these techniques in business and industry. Its purpose is to explain briefly, by means of simple examples, how these methods function and to indicate the fields of application

Many problems confronting management have these characteristics in common: the random arrival of items, or customers, who wait for service, and the uncertainty about the length of time needed for the servicing operation.

If there are too few servicing facilities obviously queues will form and these will result in loss because impatient customers will leave or material will be held up. On the other hand, and equally obviously, if there are too many facilities equipment will be left standing idle.

Problems of this kind are known, understandably, as waiting-line or queueing problems and no management is unaware of the need for reducing to a minimum the costs of both idle time and waiting time.

The problem is not solved by providing just sufficient servicing facilities to meet the average demand. The arrival of items or customers is erratic; hence there will still be times of congestion and times of idleness.

An example of this type of problem is how to find the best size for a fleet of delivery vans. If the fleet is too small, the goods to be delivered will pile up in the despatch department and additional costs will be incurred because of the delay (use of overtime, dissatisfied customers, etc.). On the other hand, if the fleet is too large, some vans will not be used—consequently the surplus vans represent an over-investment of capital.

Statistics and probability theory provide methods for solving many problems of this kind. One of these techniques is called the "Monte

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techniques

.... the Monte Carlo method and linear programming

Carlo method." As the name suggests, it serves as a natural tool for the solution of problems where chance plays a part—where events happen in a random or unpredictable manner. The fundamental idea of the method is simple and not new. Its unusual feature is that the statistician himself produces data by simulating the arrival and servicing of items under different conditions and calculating the average rate of arrival and servicing. The average waiting time per item or customer and the average length of the queue necessarily depend on the ratio of the rate of arrival to the rate of servicing. Hence, by investigating many different arrangements, it is possible for management to select the servicing policy that will minimize the two cost elements.

Use of computers

In principle the simulation process can be carried out by using random number tables or by drawing numbers out of a hat. In most situations, however, a very large amount of data is needed to obtain a reliable estimate of the effects of the operation being studied and a high-speed electronic computer is indispensable for the simulation of sufficient data in a reasonable time. Indeed, but for the development of electronic computers, it would be impossible to exploit the power of the Monte Carlo technique fully. Simulated data, equivalent to many months of actual operation, can be produced quickly and at a relatively low cost. Changes corresponding to different policy decisions can be made, their effect calculated and their merits compared. It is this attribute of "decision experimentation" which makes the Monte Carlo method particularly useful to management in arriving at a solution to the problem.

Another feature is that it is not necessary to make simplifying assumptions at the expense of the real situation as is nearly always done when an exact mathematical solution of the problem is attempted.

An example may help to clarify matters and will demonstrate how the method is actually applied. The example is based on a paper by W. N. Jessop,* considerably modified here in order to provide a very simple illustration.

A plant has two systems of the same type, both of which are serviced in turn by a single auxiliary machine (for example, a mechanical charger or loader). The time needed by the auxiliary machine to perform the service is always the same, but it is not possible to predict when the two systems will require this service. Thus one factor of the operation is not under the control of the management and costly production time is lost whenever one system waits while the machine is engaged at the other.

What the management wishes to know is the balance between the cost of lost time due to such events and the cost of investing in and operating a second auxiliary machine. For this purpose it will obviously be necessary to know the average loss of time during a specified production period —say, one week.

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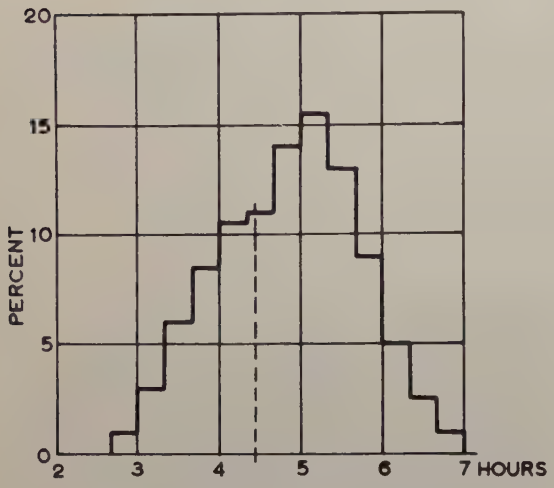
*Applied Statistics, Vol. 5, pages 158 to 165.

First, how often are the services of the auxiliary unit required? The necessary data are obtained from past works records and are expressed as a frequency distribution graph of the type shown below.



DISTRIBUTION OF TIME INTERVALS

The production system requires the services of the auxiliary machine every few hours and this information is best expressed as the intervals, measured in hours, that elapse between two successive demands. These values are indicated by the horizontal scale of the graph. Over a period of time reliable figures will be obtained of the number of intervals that occur of three hours' duration, four hours' duration, and so on. This is shown by the vertical scale of the graph where the percentage a particular interval represents of all intervals is indicated. For example, the graph shows that five per cent of all intervals are between 6 hours and 6 hours 20 minutes duration. In other words the graph shows the frequency with which intervals of a certain duration occur.

Once the performance of a production system has been expressed in this way the simulation of demands for the service of the auxiliary machine is carried out in the following manner. A number between 0 and 1 is selected at random. (That is, each number in this range has the same chance of being chosen.) Suppose the number selected is 0·32. From the graph one can easily determine which interval has the property such that 32 per cent of all the other intervals are shorter. In other words, where can a vertical line be drawn on the graph such that the area enclosed to the left of the line represents 32 per cent of the total area under the graph? This interval is taken as a sample value. In this particular case the interval is 4 hours 25 minutes. If one continues in this way a sequence of intervals, sampled at random, is generated.

To each interval is added the fixed period it takes the auxiliary machine to service the system. Then a successive addition is performed to determine at what times throughout the week the auxiliary machine will be occupied in servicing the system. This calculation is then repeated for the second production system to obtain the times during the day when it will require the services of the auxiliary machine.

Comparing results

By comparing these two results it is now possible to calculate the productive hours that will be lost because one system is using the machine when the other needs it. The comparison will also show the number of hours during which the auxiliary machine would be idle because neither system required its services.

If the calculation is repeated a large number of times a good estimate is obtained of the average losses and, consequently, the costs that would be incurred in actual practice.

It will have been observed from the example given that there are two phases in the data-simulation process. First, the generation of sequences of random numbers in the range from 0 to 1, each being selected with the same probability. Secondly, the construction of sample values according to the probability distribution of the intervals.

Generation of random numbers

In many applications of the Monte Carlo method a large number of samples is required and the use of high-speed electronic computers therefore becomes indispensable if the simulation process is to be performed in a reasonably short time. Much theoretical work has been done on the generation of random numbers by the computer itself and a computer can be programmed to do this. The point that sequences of numbers so generated cannot, in fact, be strictly random does not appear to affect the calculations. Once it is generated the random number is transformed by the computer into a sample value according to the probability distribution.

An unusual and difficult business problem, successfully solved by the Monte Carlo method, was the following: it was desired to find the optimum number of salesmen and regional offices required to get in touch with at least 80 per cent of all potential customers in areas of different sizes. The element of chance in this extremely difficult problem was introduced by the uncertainty of establishing contact with the customer.

There are other applications covering a fairly wide field which demonstrate the power of this technique. It solves problems where direct numerical methods fail; it should not, however, be used in preference to exact methods, when these are available.

So much for the Monte Carlo method; now let us consider another powerful mathematical technique—linear programming.

Linear programming may be described as a method of finding the optimum way of arranging a number of interdependent activities. "Optimum" will generally mean most economical, for linear programming is applied to situations where resources are, in some sense, limited. With this method the best of several possible courses of action is selected in a definite way, not by trial and error.

Calculations

The importance of linear programming lies in its relative simplicity and the fact that it can be applied widely. No more than ordinary arithmetical processes are necessary. Problems of moderate size can be dealt with either by hand or by mechanical calculating machines, but for those of large dimensions high-speed computers are required.

First, it is necessary to create a mathematical model of the situation being investigated. To do this there must be some means of measuring each of the interdependent activities. If the model represents a production process the level of each activity may be measured by the amount produced. The special feature of linear programming is that each kind of input into an activity and each kind of output is regarded as proportional to the level of activity. If this assumption is not justified by the real-life situation, linear programming is not applicable.

It happens sometimes that, although this condition of proportionality does not strictly hold, it is approached sufficiently closely for a useful approximate solution to the problem to be found. For example, the total costs of production are seldom, if ever, proportional to the quantity produced because there are cost elements which are more or less independent of the quantity manufactured (overhead charges, cost of setting up machines, etc.). However, with a large volume of production, these "independent" cost elements may become small in comparison with the "proportional" costs, and then linear programming provides good approximate solutions.

The procedure will be demonstrated by means of a fictitious example relating to that important class of problem called "Transportation Problems" for which a special method of solution has been developed. It must be stressed, however, that the example is intentionally simple, constructed solely for the purpose of demonstrating the method; normally problems are more complex and certainly larger.

TABLE 1

Cost of transport				**Warehouse requirements in units**
	From factory			
To warehouse	**A**	**B**	**C**	
H	£3	£5	£8	100
K	£4	£6	£9	80
L	£5	£6	£10	50
M	£6	£7	£11	60
N	£8	£9	£7	40
Factory capacity in units	110	140	80	330

Three factories of a manufacturing concern —A, B and C—supply five warehouses situated in various parts of the country. Table 1 shows the cost (in pounds sterling) of transporting one unit of production from each factory to each warehouse. It also shows the requirements for a given period, say, one month, of each warehouse and the productive capacity of each factory. It is assumed that the total requirements of all five warehouses equal the total output of all three factories. It is further assumed that the cost of production per unit is the same in all factories. The problem, of course, is to determine how much to send from each factory to each warehouse so that the total transportation cost is a minimum.

SCHEDULE 1

Number of units sent

To warehouse	**From factory** A	B	C
H	100		
K	10	70	
L		50	
M		20	40
N			40

TOTAL COST — £1,920

The first schedule (shown above) provides a possible plan. The total cost of distribution is £1,920. This scheme fulfils all the conditions in respect of capacities and requirements. It has been drawn up with an eye on the cheap transportation rates. For example, the requirement of warehouse H is met by factory A at the lowest rate of £3, and so on. But how does one know that other advantageous routes, yielding a lower total cost, have not been overlooked? The answer is obtained by comparing the costs of the direct and indirect routes.

In the particular example given here, the cost of transporting one unit from factory C direct to warehouse K is £9 (Table 1). One could also transport one unit from C to K indirectly, *using only those routes already included in Schedule* 1. For example, transport the unit from factory C to warehouse M, then from M to factory B and finally from B to warehouse K. How much would this cost per unit? It costs £11 to send a unit from C to M, and £7 from M to B, and £6 from B to K. However, it is not actually necessary to send the unit from M to B; a similar result can be obtained by sending one unit fewer to M. The indirect cost of transferring a single unit from C to K in this way is therefore £11 + £6 − £7 = £10 which is greater than the direct cost of £9. Now the mathematics of programming shows that, for a particular schedule, if the cost of transportation over a direct route, not included in the plan, is less than the corresponding indirect cost implied by that schedule, then a better method of distribution exists. This convenient rule results from the special character of the transportation problem; its proof, although simple, will not be given here.

How is the existing pattern modified? It is obviously advantageous to send units direct from C to K and rearrange the distribution pattern accordingly. Therefore, 40 units are sent direct from C to K and the other necessary alterations, which can be easily determined, are made. This is shown in Schedule 2.

SCHEDULE 2

Number of units sent

To warehouse	**From factory** A	B	C
H	100		
K	10	30	40
L		50	
M		60	
N			40

TOTAL COST — £1,880

The cost with Schedule 2 is £1,880. This is less than Schedule 1, but it cannot be said yet that it is necessarily the cheapest. To find out whether it is or is not, all the indirect transport costs for this particular pattern of distribution must be calculated and compared with the direct costs in Table 1. Again, if any of the indirect costs are higher than the corresponding direct cost, a better distribution plan exists. This better plan may be found by choosing that route for the new schedule where the difference between the indirect and direct costs is largest and rearranging the distribution pattern in the manner indicated. In this way, by stages, an optimum solution is reached until none of the indirect costs is higher than the corresponding direct costs.

SCHEDULE 3

Number of units sent

To warehouse	From factory A	B	C
H	60		40
K	50	30	
L		50	
M		60	
N			40

TOTAL COST — £1,880

This very simple problem has been solved in two stages. The solution is an optimum, rather than *the* optimum, because Schedule 3 sets out a transportation plan at the same total cost of £1,880. It sometimes happens in linear programming that there is more than one optimum solution.

Differences in production costs at the factories can also be allowed for in the programme. It is even possible to take account of the more complicated situation where the requirements of the warehouses vary in different periods. The management would then want to know whether it is cheaper to transport over routes at low costs during quiet times and incur increased storage costs (and possibly greater manufacturing costs by having to advance production plans) or to transport over the more expensive routes during busy times.

The procedure used for solving transportation problems can sometimes be applied to situations which have nothing to do with transportation. The personnel assignment problem is an example of a transportation problem being used in this wider sense. It is desired to allocate a certain number of people to the same number of jobs, and it is assumed that each person's aptitude for each job can be rated by means of some test. The problem amounts to finding the allocation which uses the available talents of the people, as expressed by their ratings, most efficiently.

A few remarks on the role of computers in linear programming calculations may be of help. Calculations for smaller problems can be done by hand or desk machines, particularly if the problems are such that there is an easy method or a short cut. In practice, however, problems are often very large and dimensions up to 100 by 1,400 have occurred (the transportation example just considered has dimensions 5 by 3). High-speed electronic computers then become indispensable if a solution is to be obtained in a reasonable time. Standard programmes for at least one general method and for the transportation type of problem are available for many electronic computers. It would be a mistake, however, to think that only fast computers are essential to obtain a quick solution. It is also desirable to exploit the special nature of a particular problem in order to find short cuts and consequently save time. This point has been stressed by many research workers in this field.

Applications of linear programming extend over a fairly wide area and it may be of value to mention a few particularly successful ones. For example, a problem in the chemical industry that has been solved by linear programming is the well-known gasoline blending problem—how to operate an oil refinery so that profits are a maximum. It is possible by means of linear programming to determine how much to produce of each grade of oil to achieve this under the prevailing conditions, such as distillation capacity, availability of crude oil and relative profit margins. It has been estimated that some large Californian oil companies have achieved savings of from 3 to 3½ million dollars yearly by adopting optimum production programmes.

Other applications

Other applications are: production scheduling, one version of which concerns the problem of balancing the costs of extra production at overtime rates against the inventory storage costs, so as to minimize the sum of the two; warehousing problems arising from restrictions imposed by warehouse capacity on the exploitation of trends in the buying and selling markets. There are also problems connected with financial investments which can be solved by linear programming.

The requirement that there is a linear relationship between all the interdependent factors does somewhat restrict the scope of the technique and can cause it to be misused. Nevertheless, when properly applied, linear programming is very valuable and its application in commerce and industry may be expected to grow.

Model of a KDP 10 data processing installation

The KDP 10

English Electric's new commercial data processing system designed to utilize the high data input and output speeds possible with magnetic tape

Something of a dark horse in the computer industry, English Electric, unlike the majority of other manufacturers, have not been so active in producing commercial data processing systems as they have been in providing computers for scientific use. Although their successful Deuce computer was adapted for commercial work, the KDP 10 represents the company's first serious bid to obtain a share of the expanding commercial market. This is remarkable because English Electric were one of the first to start designing and building electronic digital computers in Great Britain. As early as 1948, the company, in collaboration with the National Physical Laboratory, were constructing a computer known as the Pilot-Ace. From this machine the Deuce was developed. Over 25 Deuce computers have been installed and nearly all are engaged on scientific and engineering problems. Now production has started on KDP 10 commercial systems and the first is scheduled for delivery in the middle of 1961.

Based on a design by the Radio Corporation of America, the KDP 10 system has been modified to suit the requirements of European users. It falls into the medium-to-large computer category. The smallest system it would be practicable and profitable to operate will cost about £180,000. From this minimum figure prices rise to a maximum of approximately £500,000 for the most extensive and comprehensive system possible.

The design of the KDP 10 system can best be appreciated if it is remembered that it exploits, to the full, all the advantages possessed by magnetic tape.* Of these, the most important is that data can be read from, or recorded on, magnetic tape faster than any other medium at present available.

Where large quantities of data are handled, as is characteristic with commercial jobs, the amount of work a computer can do is often determined by the speed at which data can be passed in or out of the machine. With the KDP 10 all input data are first transcribed on to magnetic tape. This operation is performed independently of the computer (off-line operation). Because so much business information is already recorded on punched cards the transcription unit built for use with the system translates data from punched cards to magnetic tape. It handles 80-column punched cards at the rate of 450 a minute.

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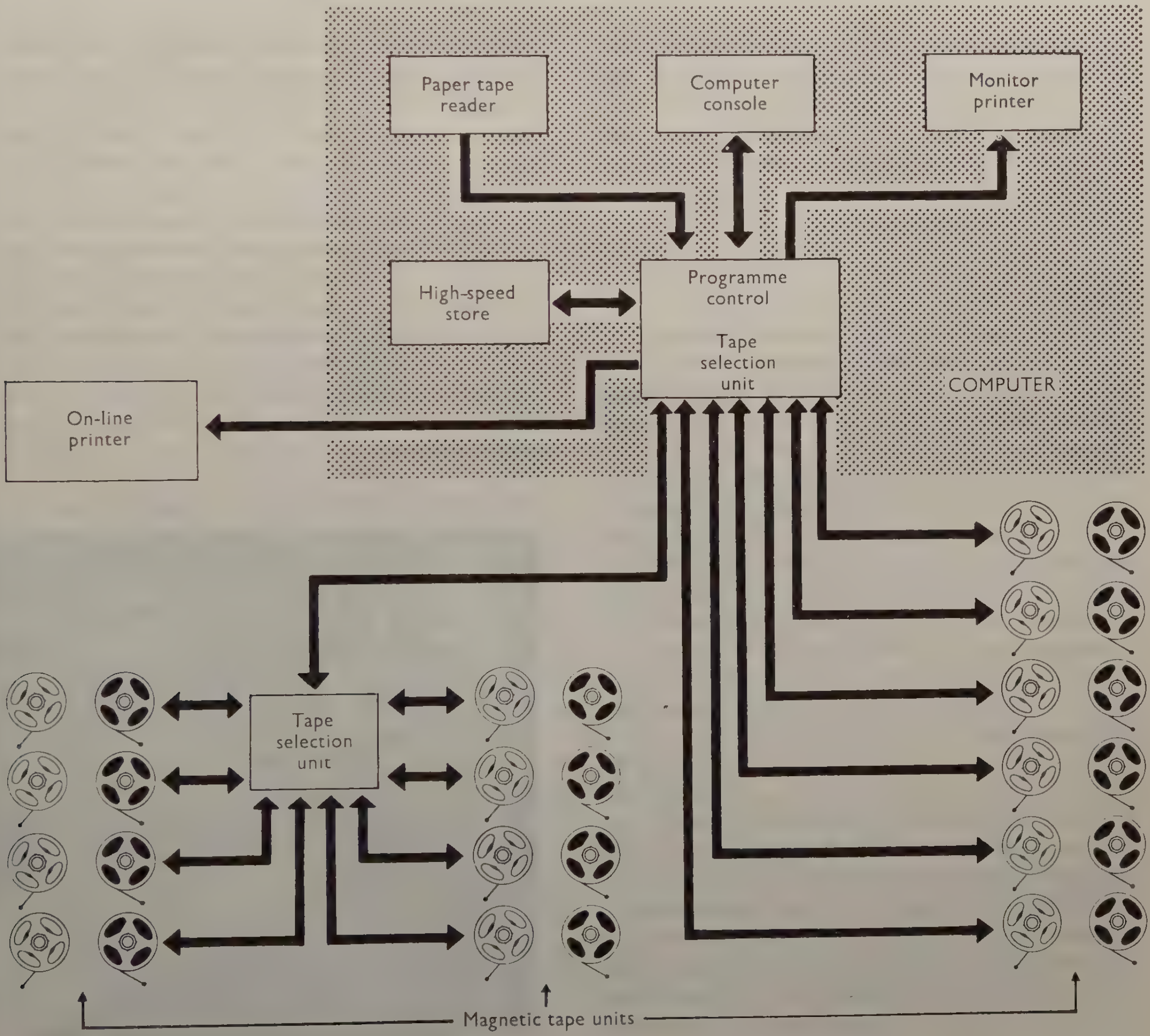
*See "Magnetic tape—the commercial document of the future," *Data Processing*, October-December, 1959.

Also in the interests of speed, all output data are recorded directly on magnetic tape. These output tapes are then removed from the computer and transferred to data transcription units. Two transcription units are available. One punches 80-column cards at 150 a minute and the other prints data at 600 lines a minute.

Another requirement of a commercial data processing system is that it should be able to store large quantities of information—and magnetic tape is a good medium for this purpose also. High performance tape decks are used. Up to 62 tape decks can be fitted.

To conserve tape, and improve computer operating speeds still further, data may be recorded in variable length blocks. This means that the length of tape occupied is proportional to the amount of data recorded, in contrast with the practice of recording data in blocks of fixed length, where the block length is chosen to accommodate the longest entry.†

Another attribute of the KDP 10 system of great interest to users is that the system can be expanded at a later date with the minimum of inconvenience. For instance, it is not necessary to modify the circuit arrangements nor is any engineering work involved when extra magnetic-



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†See "Filing business data on magnetic tape," *Data Processing*, April-June, 1959.

Data are read from or recorded on magnetic tape at 33,333 *characters a second*

tape decks are added to an installation. The computer need be taken out of service only for the time necessary to make the electrical connections. In much the same way, the capacity of the immediate access store can be increased by the addition of extra magnetic-core information storage units.

Machine code

A 6-bit code is used in the machine to represent all the alphabetical letters and decimal numerals, plus certain mathematical signs and other symbols—a total of 64 separate characters.

Although input data are recorded on magnetic tape, one other input reader is connected directly to the computer. This is a high-speed punched paper tape unit that reads 1,000 characters a second from 7-channel tape. Data are recorded in the paper tape in the same 6-bit code used in the machine; check digits are recorded in the seventh channel. This unit is generally used for entering the programme into the computer.

A KDP 10 system comprises a programme control unit, a high-speed store, a console and a monitor printer. The programme unit controls the operation of the computer. It interprets and performs the instructions in the programme and also carries out all arithmetical operations. The high-speed store forms the central quick-access store for the computer and is built of magnetic cores. Random access can be obtained to any data recorded in this store within 15 microseconds (0·000015 second). Each store is constructed from a number of magnetic-core blocks. Between one and 16 blocks may be fitted. A block holds 16,384 characters, consequently, 262,144 characters is the maximum capacity of the largest store.

Manual control switches are provided on the console and this is the position from which the operator supervises the working of the system.

The monitor printer is an electric typewriter fitted with a 7-channel paper tape punch. It is used mainly for control purposes when programmes are being tested or the operation of the machine is being checked. Whenever data

The operator supervises the system from the console

ENGLISH ELECTRIC KDP 10 DATA PROCESSING SYSTEM CHARACTERISTICS

Number system—all alphabetical characters, decimal numbers, plus certain other symbols and signs—64 in all—represented by a 6-bit binary code

Average times for arithmetical operations:—

Addition of two 4-decimal digit numbers—315 microseconds (0·000315 second)

Multiplication of two 4-decimal digit numbers—5 milliseconds (0·005 second)

Type of programme instruction—two address

Word length—variable

Quick-access (high-speed) store—magnetic core. From 16,384 characters to 262,144 characters capacity

Main store—magnetic tape

Data input—magnetic tape read at 33,333 characters a second

Data input—punched paper tape read at 1,000 characters a second

Data output magnetic tape. Characters recorded at 33,333 a second
—printed at 600 lines a minute. Each line may contain up to 120 characters

Data conversion equipment operated independently of the computer with, or without, editing facilities.

Data input—conversion from punched cards to magnetic tape
cards read at 450 a minute

Data output—conversion from magnetic tape to:
punched cards—cards punched at 150 a minute
line printer—prints 600 lines a minute and in some instances up to 900 lines a minute. Each line contains 120 characters

are typed out by the monitor printer they are recorded simultaneously in punched paper tape.

These units comprise the basic KDP 10 system to which must be added a number of magnetic-tape decks to suit the nature of the work performed. A high-speed line printer can also be connected to the system if required.

The line printer can be operated either on-line or off-line, that is, directly by the computer or indirectly by connecting it to a separate magnetic-tape transcription unit. Up to six copies of each document can be produced. Each line may contain up to 120 characters and any one of the 64 characters can be printed at each position. When the printer is operated directly by the computer (on-line) it prints 600 lines a minute. When the printer forms part of the independent (off-line) transcription unit it prints at speeds of up to 900 lines a minute. The vertical format of the printed data is controlled by instructions read from a loop of punched paper tape contained within the printer.

Magnetic-tape units

By far the most important of the data handling units is the magnetic-tape deck. It provides bulk information storage capacity and is also used as an input output unit. Data are read from or written on to the tape at a speed of 33,333 characters a second. The magnetic tape used is one inch wide and contains 16 recording channels. Each character is recorded twice to provide a check. If an error is detected when the tape is being read, it is stopped, backed-up and the faulty character is re-read. After a fixed number of re-reading sequences, if an error is still signalled the computer will stop. Many checks of this sort are performed continuously and automatically at all stages throughout the system.

Three types of data transcription unit are built for transcribing data from punched cards to magnetic tape, magnetic tape to punched cards and magnetic tape to print.

Normally data recorded on punched cards are not in the same code as that used by the machine. There are two methods of performing the necessary translation. One is to read the data from the card and record it in the same form directly on magnetic tape; later a translation programme within the computer converts the data into the correct machine code. Alternatively, the transcription unit can be equipped with an editing unit; then during a transcription sequence the editing unit translates and records the data directly on magnetic tape in the correct code.

Transistors and printed wiring are used throughout the KDP 10 system. Circuits are mounted on removable plug-in cards for ease of servicing.

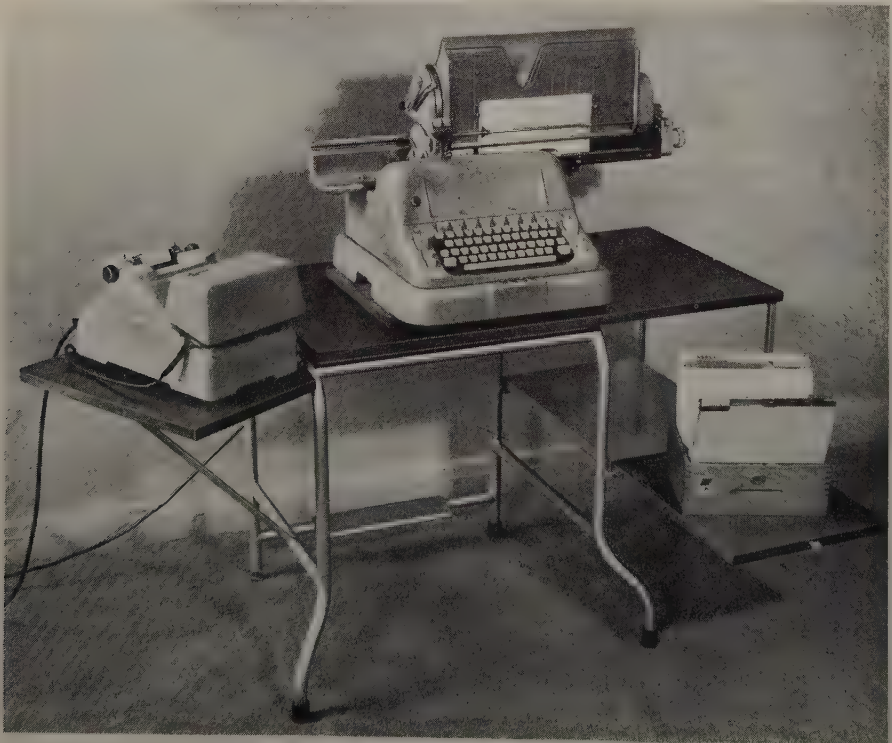
A library of standard programmes will be made available and special automatic programming codes are being developed. The first KDP 10 commercial data processing system is now being built at the Kidsgrove Factory of the Data Processing and Control Systems Division of the English Electric Company and, as stated earlier, will be completed during 1961.

Mechanized accounting for the smaller office

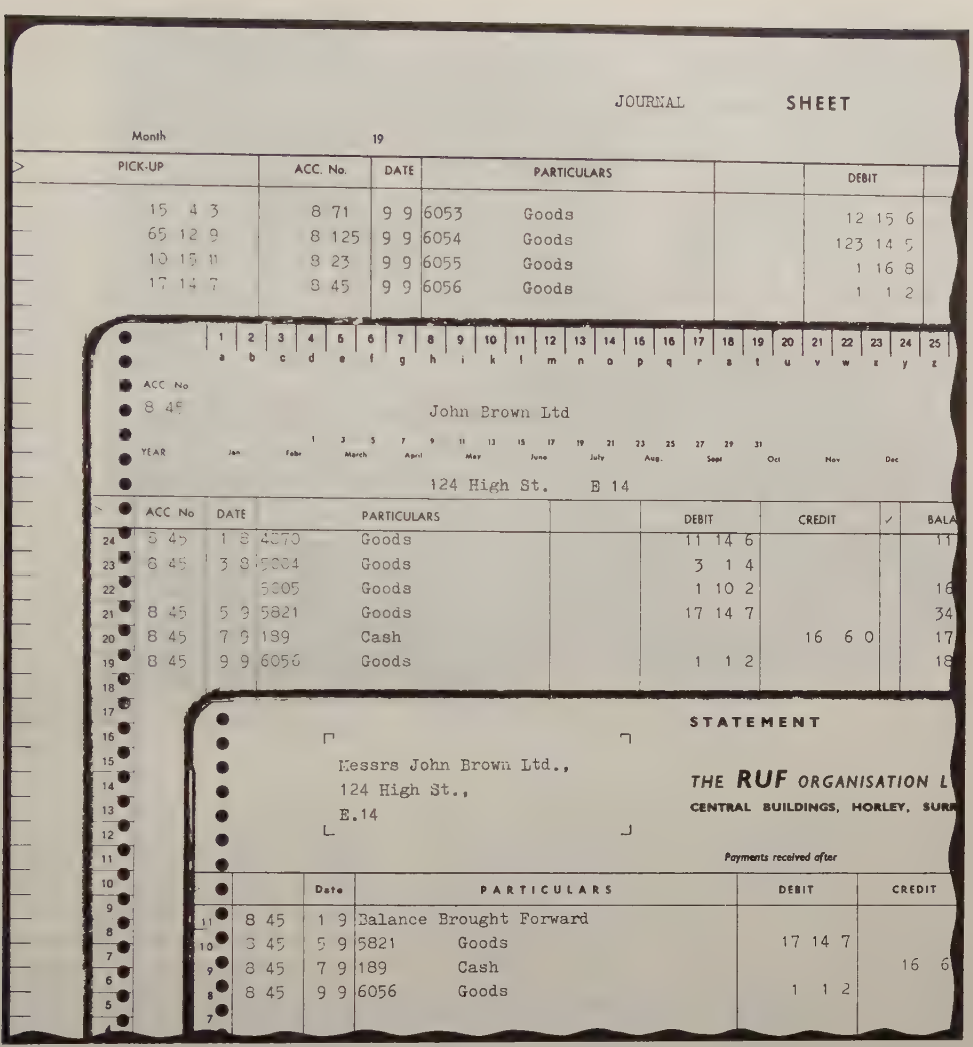
A simple system that can be operated by any competent typist

A book-keeping typewriter to which can be fitted a document feed mechanism and a standard single-register adding machine—all linked together in a common system. When there is insufficient work, the system can easily be dismantled and the typewriter and adding machine used separately. The three basic units are described in detail and also the method of operation and typical applications

An accounting system that can be created by assembling together various standard business machines . . . . An attractive idea, but few installations of this type exist. One that has been designed so that this is possible is marketed by the Ruf Organization Limited. The system is simple in concept and can be operated by any competent typist. It consists of a standard book-keeping typewriter to which a dual document feed mechanism and a single-register adding and listing machine can be connected, as conditions warrant. The document feed mechanism speeds up the process of feeding forms in and out of the typewriter, and limited automatic calculating facilities are provided by the adding machine. Incidentally, the latter may be either a sterling or a decimal machine to suit the application.



An adding machine linked to a standard book-keeping typewriter. The typewriter is fitted with a dual document-feed mechanism



JOURNAL SHEET

Month 19

PICK-UP	ACC. No.	DATE	PARTICULARS			DEBIT
15 4 3	8 71	9 9	6053	Goods		12 15 6
65 12 9	8 125	9 9	6054	Goods		123 14 5
10 15 11	8 23	9 9	6055	Goods		1 16 8
17 14 7	8 45	9 9	6056	Goods		1 1 2

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
a b c d e f g h i k l m n o p q r s t u v w x y z

ACC No
8 45

John Brown Ltd

YEAR Jan Febr March April May June July Aug. Sept Oct Nov Dec
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31

124 High St. E 14

ACC No	DATE	PARTICULARS			DEBIT	CREDIT	✓	BALA
8 45	1 8	4070	Goods		11 14 6			11
8 45	3 8	5004	Goods		3 1 4			
		5005	Goods		1 10 2			16
8 45	5 9	5821	Goods		17 14 7			34
8 45	7 9	189	Cash			16 6 0		17
8 45	9 9	6056	Goods		1 1 2			18

STATEMENT

Messrs John Brown Ltd.,
124 High St.,
E.14

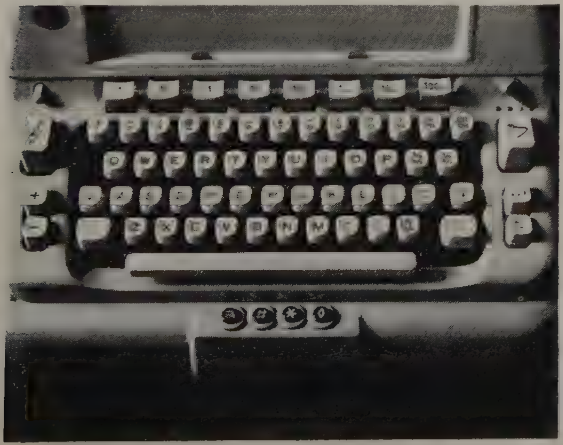
THE **RUF** ORGANISATION L
CENTRAL BUILDINGS, HORLEY, SUR

Payments received after

	Date	PARTICULARS		DEBIT	CREDIT
8 45	1 9	Balance Brought Forward			
8 45	5 9	5821	Goods	17 14 7	
8 45	7 9	189	Cash		16 6
8 45	9 9	6056	Goods	1 1 2	

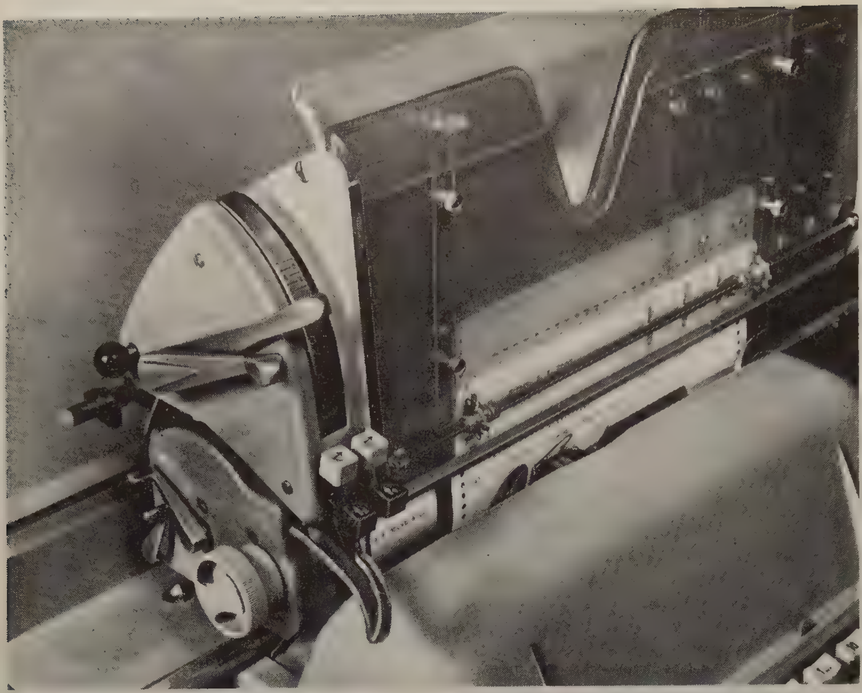
The two documents with perforated margins can be positioned independently in the typewriter by the Intromat document-feed mechanism. This saves the typist from having to arrange and feed the three forms as a complete set

Below the typewriter keyboard are four buttons used when the adding machine is being controlled manually



For the small business, or for self-contained departments within firms, this equipment offers many advantages. Not the least of its attractions is its price. A complete installation of the units described costs between £500 and £650, depending upon the additional features required. It can be operated by any typist after half an hour's instruction, and, if there is insufficient work to keep the complete system busy throughout the day, it can be dismantled easily and quickly and the typewriter and adding machine used independently.

The heart of the system is the typewriter. This is a standard book-keeping model fitted with 12 numeral keys (0 to 11) and eight tabulation keys. Three versions are manufactured. One has a manual keyboard, the second a manual keyboard with an automatic electrically operated carriage return, while the



The two documents placed in the pockets of the Intromat are fed independently into position by pulling down the two levers on the left

third is an all-electric machine. Prices are £100, £120, and £220 respectively. The most popular machine for book-keeping work is the second because for only a small increase in cost, one of the most tiring and time absorbing typing operations—returning the carriage and line-spacing—is performed entirely automatically at the touch of a button.

Another action that occupies a considerable proportion of a typist's time is the collecting, collating, indexing and feeding of the various accounting documents into the typewriter. It has been estimated that, where only a few entries are typed on each form, up to one-third of the typist's time is spent in this way.

Many years ago Ruf developed a device, called the Intromat, to speed up this work. With this unit, which fits on top of the typewriter carriage, two documents can be accurately and independently fed from the front round the platen of the typewriter. When in position, these two forms cover a third document, which has been fed round the platen of the typewriter from the rear in the conventional way.

The advantage of an Intromat feed is that all three documents in the typewriter can be positioned independently of each other and, after completion of an entry, the two documents controlled by the Intromat can be removed quickly and two more inserted ready for the next entry to be made. The typist no longer has to wind out the completed set of forms, laboriously assemble the new set and wind them in over the platen of the machine.

With this unit, identical entries are made on three different documents simultaneously. A good illustration of the use of a book-keeping typewriter fitted with an Intromat is provided by insurance broking. In this work, a broker has to record details of transactions made by him between a large number of clients and various insurance companies. For this purpose, details of each transaction have to be entered on at least three documents. These are: the broker's day book page—this contains a summary of each day's transactions; the client's ledger card—on which appear details of all transactions made on behalf of a client and the state of his account; and a company's ledger card—on which are recorded all transactions concluded with a particular company and the amounts owing.

Entries are made on these three documents simultaneously. First, the day book page is fed round the typewriter platen from the rear. This form remains in the machine and all transactions recorded that day will appear on it in the order in which they were made. The remaining two documents—the ledger cards for the company and the client—are placed in the Intromat and fed independently into the typewriter to the next free line on which an entry is to be recorded. After the data have been typed, the two ledger cards are ejected, leaving only the day book page in the typewriter. This is advanced one line; then the two ledger cards for the next transaction are placed in the Intromat, fed into position and the next entry completed.

Of course, if a number of entries concerning one client are to be made in a continuous sequence or, conversely, a number of entries concerning one company are to be recorded, the appropriate ledger card can be retained in the Intromat and advanced one line, together with the broker's day book page. Meanwhile, the ledger card to be changed is ejected from the Intromat and replaced by another.

Apart from the obvious economies of completing entries on three documents at once, a great deal of detailed checking is avoided—work that often takes longer to complete than the actual typing operation.

Both manual and electric versions of the Intromat are built, and both can be fitted retrospectively, as accessories, to any of the three book-keeping typewriters already described.

Mechanical operation

Mechanically, an Intromat is quite a simple device. The manually operated unit consists of two Perspex pockets in which the documents are placed. On the left are two levers to feed the documents into position in the typewriter. All stationery used with the Intromat has sprocket holes punched down both edges, similar to those provided on conventional continuous stationery. Also, down the margin is printed a list of numbers which identify the lines on the document. A scale bearing numbers which correspond with the numbered lines on the form is fitted next to the manual feed levers.

To use the Intromat, the typist places a document in one of the pockets and reads from the margin the number of the line on which the next entry is to appear. The feed lever is then pulled down until the pointer is opposite the correct line number. The lever is connected by a mechanical drive to a sprocket wheel, which is located at the bottom of the pocket in which the document is placed. As the lever is pulled down, the sprocket wheel rotates, engages with the sprocket holes punched in the form and feeds the form into the typewriter. When the pointer indicates the right line number, the document will be positioned correctly in the typewriter.

In a similar way a second document placed in the other pocket of the Intromat can be fed into the typewriter and positioned independently of the first by the operation of the second feed lever.

After an entry has been made, the action of returning the typewriter carriage either causes all the documents to be automatically moved forward one line or, alternatively, controls can be set so that, when the carriage returns, the Intromat ejects both documents back into the feed pockets or ejects one of the documents and advances the other a line. A combination of these actions allows most document positioning operations needed for routine clerical work to be performed entirely automatically.

Control keys

Four control keys, situated just beneath the feed levers, are used when manual control over these actions is needed. One pair of keys is provided for each feed mechanism. When one of the keys is depressed, the document is ejected from the typewriter, and if the other is depressed, the document is advanced one line.

More often than not, the three forms in the typewriter will be set on different lines. Consequently, the typist must be given some indication when the last line of a document is reached. In the case of the two forms controlled by the Intromat, as soon as the last line is filled the document is ejected automatically from the typewriter. With the third document however, that is, the one wound round the platen, when the last line but one is reached, a red light, on the front of the typewriter, is switched on. In this way, a typist cannot continue to make entries without realizing that one of the documents has been filled.

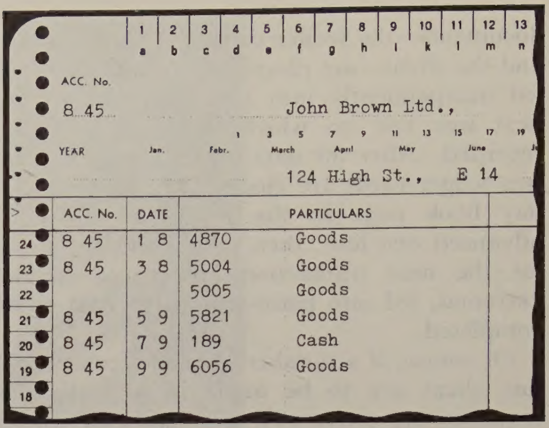
When the two forms are placed in the Intromat it is not necessary to interleave carbons, as fabric ribbons are held between the documents at the typing position. These ribbons are suspended from thin metal strips that clip on to the frame of the Intromat. Approximately 700 entries can be made before the ribbons have to be replaced. Renewal is a simple job and only takes half a minute.

The Intromat positions documents so accurately that an entry can be typed, the documents ejected from the typewriter, fed once again to the same line and the entry repeated without the overtyping being apparent.

The electric Intromat operates in exactly the same way as the manual unit except that the documents are fed into the typewriter to the correct line entirely automatically. A document dropped into the pocket of an electric Intromat switches on a motor which drives the sprocket wheel and feeds the form into the typewriter. A second switch senses the edge of the form and, when a small perforation in the margin is reached, the drive motor is switched off. The document is now correctly positioned in the typewriter ready for the entry.

After the entry has been made and the document is about to be ejected, a solenoid-operated cutter perforates the margin to

An electric typewriter equipped with an electric Intromat



1 2 3 4 5 6 7 8 9 10 11 12 13
a b c d e f g h i k l m n

ACC. No.
8 45 John Brown Ltd.,

1 3 5 7 9 11 13 15 17 19
YEAR Jan. Febr. March April May June
124 High St., E 14

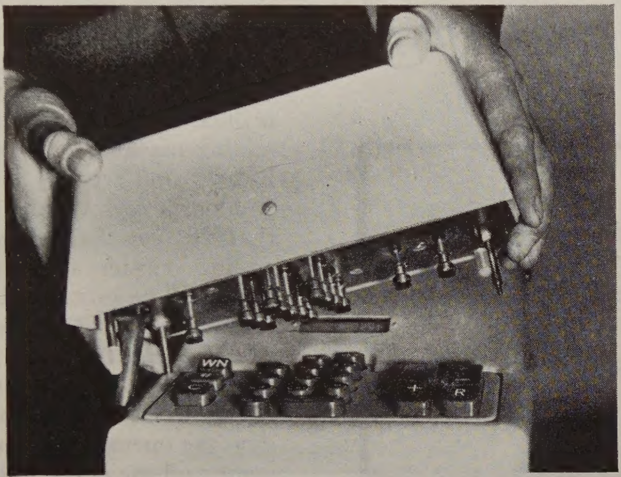
	ACC. No.	DATE	PARTICULARS		
24	8 45	1 8	4870	Goods	
23	8 45	3 8	5004	Goods	
22			5005	Goods	
21	8 45	5 9	5821	Goods	
20	8 45	7 9	189	Cash	
19	8 45	9 9	6056	Goods	
18					

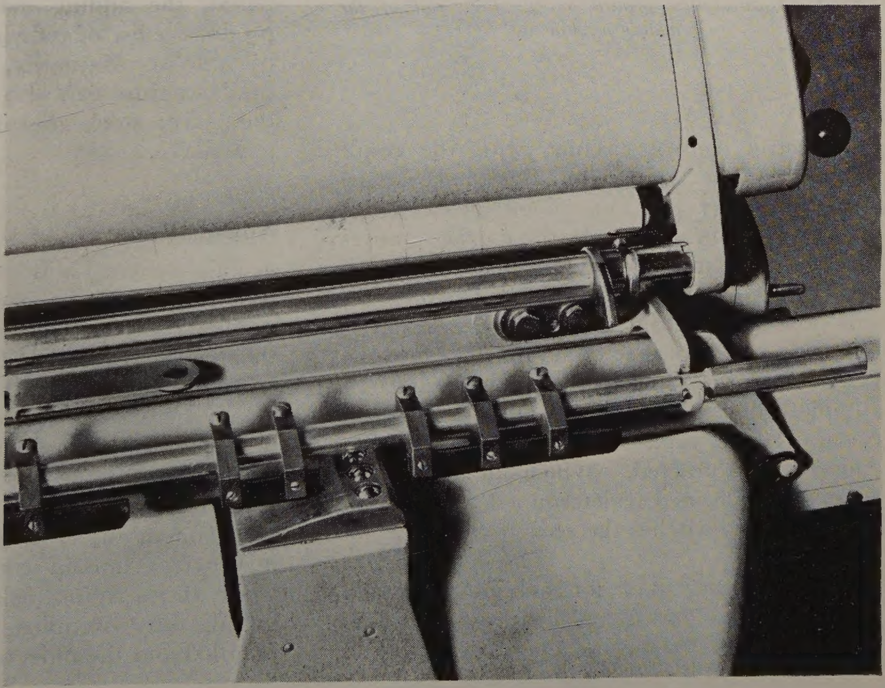
In the margin at the extreme top left of the document can be seen the small perforations made whenever the document is ejected from the electric Intromat

The standard Odhner single-register adding machine which can be connected to the typewriter by the solenoid box on the right indicate the position to which the form is to be fed the next time it is placed in the Intromat.

An adding and listing machine can be connected to the book-keeping typewriter just described. Totals can be compiled on this machine and, in addition, a record of all entries made is printed on a tally roll. A perfectly standard office machine is used for this purpose—an Odhner single-register decimal or sterling adding machine. The electric circuits that connect the two units together are housed in a special base on which the typewriter stands.

These electrical control circuits are extremely simple. A number of microswitches are fitted in the base unit and each one is mechanically connected by a thin rod to one of the figure keys of the typewriter. In turn, each microswitch is connected by an electrical circuit to a solenoid-operated push rod. All these push rods are mounted in a box fitted over the keyboard of the adding machine. When one of the figure keys of the typewriter is pressed, a microswitch is closed and the solenoid to which it is connected is energized. This causes a push rod to depress the corresponding figure key on the adding

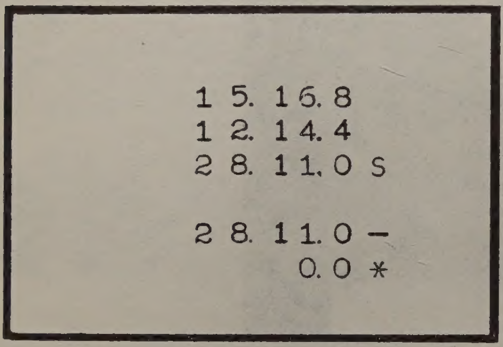

When the box is placed on the adding machine the solenoid-operated push rods rest on the keys


Cams on a bar fitted to the rear of the typewriter carriage automatically control the operation of the adding machine

machine. The figure is then entered into the register of the adding machine and, at the same time, is automatically printed on the tally roll.

It is not necessary for all numerical data entered on the typewriter keyboard to be recorded in the adding machine so a control bar is fitted to the typewriter in order that the data required can be selected.

The control bar is at the rear of the typewriter carriage and passes above a group of three microswitches as it moves with the carriage from one side to the other. Cams fitted to this control bar depress, in turn, two of these three microswitches whenever the carriage moves the document to a position where the entry is to be recorded on the adding machine. The first microswitch to be closed turns on the power to the electric control circuits, with the result that all numerical data entered on the keyboard of the typewriter are entered on the keyboard of the adding machine. As the carriage moves the pence column of the document past the typing position, another cam on the control bar will close a second microswitch. This operates the "motor" bar of the adding machine and the value entered on the keyboard is transferred automatically into the machine's register. Naturally, the value recorded may be either added or subtracted. Which of these two actions is performed is determined by which of the two microswitches the second cam is set to operate.



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15.16.8
12.14.4
28.11.0 S

28.11.0 -
    0.0 *
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Zero proof calculation printed on the tally roll of the adding machine

A control bar is made for each job performed on the machine and is replaced every time the job is changed. When the action of the adding machine is being controlled by the operator, four push buttons fitted to the base unit, beneath the typewriter keyboard, are used.

The interconnected adding machine and book-keeping typewriter (this assembly is called the Ruf Adjutant) can be employed in a variety of ways. One method is to use the facility for calculations provided by the adding register to increase the speed at which entries are made on documents. A typical example is up-dating accounts.

Zero proof

When the existing balance is picked-up and typed it is recorded simultaneously in the register and also printed on the tally roll of the adding machine. A new credit or debit entry is then typed and the new balance will be printed automatically on the tally roll of the adding machine. The operator reads this new balance and types it on the document. As this is done, a cam on the control bar will ensure that this new balance will be signalled to the adding register as a negative quantity. This value will be subtracted automatically from the balance recorded in the register of the adding machine and the result typed on the tally roll. If the transcription has been performed correctly the answer will be zero. If a value is printed, then the operator knows that an error has been made and the entry will have to be repeated.

When a number of cheques are being prepared, the adding machine can be used to produce a list of individual amounts, followed by a total. Naturally, many other jobs of a similar nature can also be performed. Among these are: stock control, invoice writing and payroll.

Applications

This system, built up by interconnecting standard business machines, is suitable for smaller businesses that cannot afford to equip themselves with a wide range of specialized business machinery. It is also suitable for larger firms where a number of simple routines have to be performed, but where the volume of work does not justify the purchase of more expensive machines.

As stated, any typist can operate the system; it provides limited computing facilities and, when there is insufficient work to keep the system fully occupied, it can easily be dismantled and the units used separately.